DOCUMENT RESUME

ED 055 421 EM 009 268

TITLE The Financing and Organization of Computing in Higher Education: 1971.

INSTITUTION Interuniversity Communications Council (EDUCOM), Princeton, N. J.

PUB DATE 29 Apr 71

NOTE 188p.; Proceedings of the EDUCOM Spring Conference, Philadelphia, Pennsylvania, April 29, 1971

AVAILABLE FROM EDUCOM, Interuniversity Communications Council, Inc., P. O. BOX 364, Rosedale Road, Princeton, New Jersey 08540

EDRS PRICE MF-$0.65 HC Not Available from EDRS.

DESCRIPTORS Colleges; Computer Oriented Programs; *Computers; Computer Science Education; *Conference Reports; Educational Administration; *Educational Finance; Federal Programs; *Higher Education; Libraries; Medical Schools; Regional Cooperation; Time Sharing; Universities

ABSTRACT

The key issues of the EDUCOM 1971 Spring Conference were the development of new mechanisms to supply computing to colleges and of the means to deliver this computing at lower cost. In the keynote address the history of computing in higher education was reviewed, emphasizing the changes caused by the dwindling manufacturer discounts, the disappearance of National Science Foundation grants, and the general change in federal policy regarding computer funding. Two other papers were presented which reinforced the notion of radical change. One reported the development of a single centralized agency to supply computing to all the campuses in a single state; the other described the development of an independent corporation to supply computing to the university and other agencies, both educational and commercial. Thirteen parallel discussions followed the presentation of these papers. They looked at ways to perserve the existing forms of campus computer centers and at radical alternatives; the computer center as an independent organization; the regional center as an alternative to the on-campus computer; the ultimate concept of a national network of computer centers. The final discussions centered on the relationship of computing to special classes of users: administrative offices,libraries, and medical schools. (JY)

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The Financing and Organization of Computing in Higher Education: 1971

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Proceedings of the
EDUCOM Spring Conference
April 29, 1971
Philadelphia, Pa.

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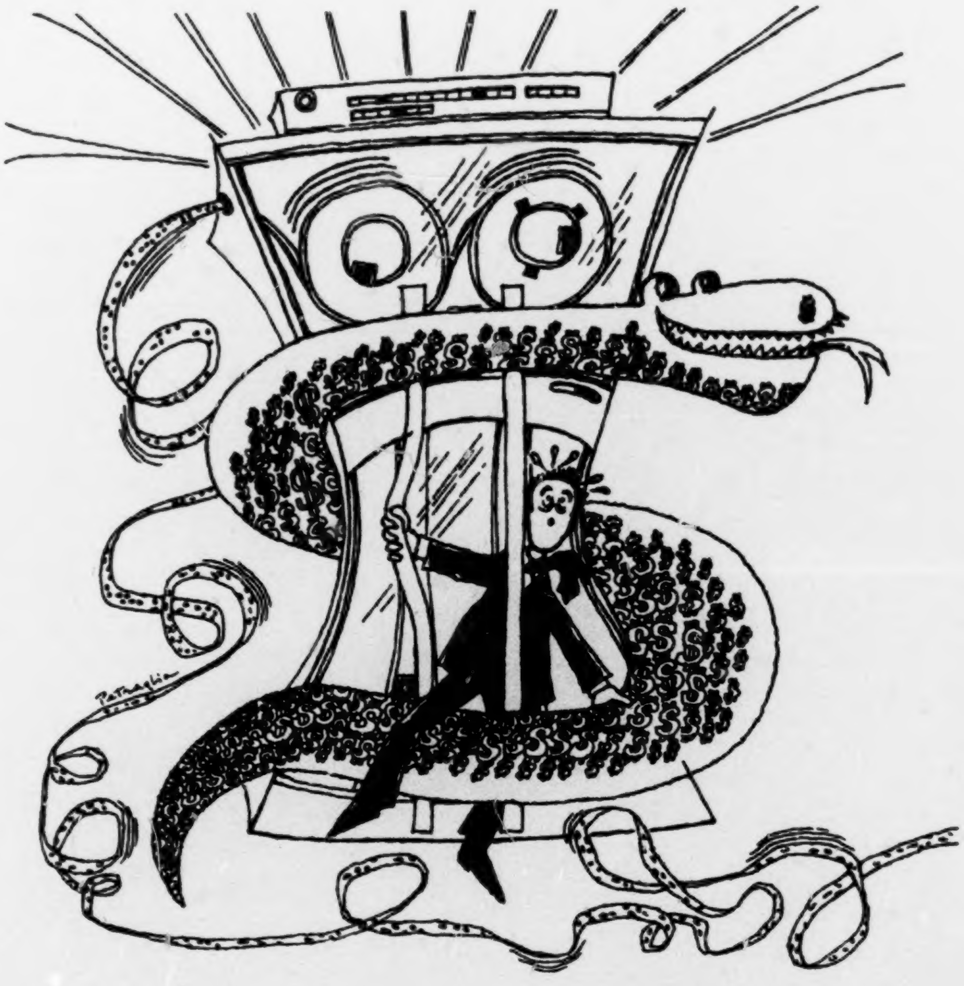

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FORWARD

Computing in higher education is currently at a crossroads. Moving forward along the same path that many colleges and universities have been traveling for the last half-dozen years may no longer be economic, sensible, or feasible.

Computing centers are being hard hit at the present time. They not only have to contend with the general financial woes of the economy and the acute budgeting problems that have beset higher education across the country, but also with the recent cutbacks and shifts in the support of computing by both government and industry. The strain they feel comes at a time when better and less expensive mini-computers make it easier for the user to have his own computer and when improved communication systems make it easier for him to use a computer elsewhere in the country.

The possible roads go off in several directions. A few universities, including some of the largest, are closing down their central computer operations or merging them with those of other institutions. Two universities have formed for-profit corporations to supply computing to their respective academic communities, while at the same time doing business on the outside. Many institutions are joining regional plans, networks, and other systems for sharing computer resources.

EDUCOM called a one-day conference to consider the situation in Philadelphia in the spring of 1971. The conference brought together concerned and knowledgeable people from educational institutions throughout the country for a discussion of the differing views and plans. The interaction was lively and illuminating. A capacity attendence, three times that initially projected, testified to the interest and timeliness of the subject.

The opening session consisted of three background papers and a panel discussion, chaired by Randall Whaley, President of the University City Science Center, which cooperated with EDUCOM in organizing the conference. This was followed by thirteen parallel discussion groups concerned with different aspects of the problem and the variety of solutions under consideration. At the concluding session of the conference members of some key government agencies presented their impressions and points of view, and they answered questions posed by the conferees.

The papers and discussions of this conference have been collected and edited in the following pages. We thank the editor of the proceedings and all of the participants at the conference for their parts in making the proceedings possible and putting it in a form in which we can make it generally available.

HENRY CHAUNCEY
President of EDUCOM

MARTIN GREENBERGER
Chairman of the Conference

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INTRODUCTION

A conference brings together a group of people concerned with common problems. The EDUCOM Spring Conference attracted people with a common interest in computing in higher education, how it is going to be supplied and how it is going to be paid for. Although many different points of view were expressed in the papers and in the discussions, there seemed to be a remarkable tight focus on the key issues announced in the title of the conference: the development of new mechanisms to supply computing to colleges and of the means to deliver this computing at lower cost.

Martin Greenberger presents the keynote clearly. His paper, the first in this volume, reviews the history of computing in higher education, emphasizing the changes that have taken place in the nature and structure of computer funding, such as the dwindling of manufacturer discounts, the disappearance of NSF facilities grants, and the general change in federal policy regarding computer funding. He concludes that computing in higher education is undergoing a radical change and that the nature of the change and the form of the emerging institutions are the necessary topics for study and discussion.

The two papers that follow reinforce the notion of radical change. Robert Mautz reports on the development, in Florida, of a single centralized agency to supply computing to all the State campuses. John Hrones describes the development of Chi Corporation, established as an independent corporation by Case Western Reserve University to supply computing to the university and to other agencies, both educational and commercial. Both are cases of academic institutions forced to find new means of providing the needed computing for research, instruction, and administration in an era of decreasing financial resources.

Part II of this volume contains summaries of the thirteen parallel discussions that followed the presentation of these three papers. They continue on the theme set by those papers: innovative management approaches, supported by available technology, as a key to growing computing needs. They appear in this volume arranged so as to exhibit some meaningful sequence for the reader. They begin with papers that describe ways of preserving the campus computer center, more or less in the form it took during the 1960's. These are followed by discussions that explore more radical alternatives: the computer center as an independent organization; the regional center as an alternative to the on-campus computer; the ultimate concept of a national network of computer centers. Finally, there are discussions that consider the relationship of computing to special classes of users: administrative offices, libraries, and medical schools.

But this logical order in the titles is an oversimplification of the actual content of the discussions. The major themes of the conference cross and recross the lines set down by the titles and the guidelines provided for the discussants. The future of the on-campus center is an important consideration in the discussion of national networks. Excellent insights into the role of the regional center are found in the sessions on more traditional structures. The mini-computer, which does not appear in the table of contents at all, crops up over and over as an alternative to more elaborate forms of service. It is as though each topic had to be discussed in the context of all the others.

Woven through these discussions are several major themes and insights that are relevant to the future of computing. These themes appear by their multiple statement to be of key importance. They represent the ideas that many of the participants brought with them, expanded and deepened in the discussion, and took away again. It may be worthwhile to point out some of them here.

1. Despite the general concern about the financing of computing, there was an insistance that there are aspects of computation more important than its cost. Computing means more than computers. It means making available to users software, documentation, and consultation across a range of application areas. The value of computation is measured in terms of service to the user as well as in terms of economical computing power.
2. If centralization of resources at the campus level is a good idea, further centralization is worth consideration. If one computer, one computer center, and one staff of specialists promise better and cheaper computing to a university, they may provide the same to a system or group of institutions -- or to a group of libraries or chemists or sociologists.
3. The mini-computer is a valuable tool that has its place in the hierarchy of resources available to the college or university. The existence of more sophisticated alternatives does not replace or supplant the small machine in those contexts where it is effective and economical.
4. A range of available resources means being able to select more than one. One can have access to regional computing and mini-computers, batch and time-shared service. The ideal of total availability, in which users have the maximum freedom of choice, was a key point in the discussion of the future national network.
5. If the user is to keep getting quality service as the center of computation moves further away (in both a geographic and administrative sense), he must have some mechanism of control: administrative, managerial, or financial. Finding such mechanisms is an important part of assuring the success of larger and more distant centers of computation.

6. Computing is an educational resource and must be dealt with in educational terms. Decisions about computers must be made in the normal decision-making process of the institution, based on a careful enunciation of institutional goals and objectives.

The final panel, printed here as Part III, returns to the issue of finance and presents three views of the role of the Federal government in financing, directing, and encouraging computing in higher education.

A new stage in the development of the use of computers for the purposes of higher education is indeed upon us. The days of free or almost free computation, of grants and discounts to create large resources of computing at the institutional level, seem to be gone forever. Computing can no longer be viewed as a resource with special privileges. It must be governed by careful management and control. Its role and use must be dictated by the needs -- and the financial realities -- of the institutions themselves.

Charles J. Mosmann
Editor

I OVERVIEW

THE DEVELOPMENT OF COMPUTING IN HIGHER EDUCATION

MARTIN GREENBERGER
Director of Information Processing
The Johns Hopkins University

This is an important time for asking questions about computing in higher education, especially about the problems that now beset it and the possible solutions. But before trying to assess the current situation and look ahead, it is instructive to examine the past for the forces and trends that may shape what is to come. Our first question is: How and when did computing in colleges and universities get its start?

The Beginning

The first automatic digital computers were built by academicians supported by government funds. Two of the earliest computers were the Atanasoff binary electronic machine at Iowa State University in the late 1930's, never fully completed, and the Aiken (Mark I) decimal electromechanical calculator, put into operation at Harvard in 1944.

At the University of Pennsylvania, J. Presper Eckert and John W. Mauchly collaborated on the first working electronic computer, the ENIAC, completed in 1946 under contract to the Army's Ballistic Research Laboratory. The next few years saw the construction of the SWAC computer at UCLA for the National Bureau of Standards, an Institute of Advanced Study machine (used also by Princeton University), the Illiac I at the University of Illinois, Whirlwind at M.I.T., Mark IV at Harvard, and a number of other computers built and supported with government funds.

This period might be considered Phase 0 in the development of computing in higher education (or, for that matter, in the development of computing everywhere). The computers were typically built to accommodate a small set of specialized applications, often for a single government client. Industry had not yet gotten into the act.

Then Eckert and Mauchly went into business for themselves and produced the UNIVAC, the first commercial computer, which was marketed successfully by Remington Rand. By 1952 IBM saw the handwriting on the wall and began manufacturing its own large- and medium-size computers, and many other firms soon entered the business.

Universities such as Cornell, Carnegie, Case, Stanford, and Wisconsin began to rent these first commercial machines in the early 1950's. Gradually the interest in using the intriguing new device expanded beyond the group responsible for its operation. Harvard economist Wassily Leontief used the Mark IV with the help of Kenneth Iverson to invert matrices for input-output analysis; Anthony Oettinger used the same machine to study the problem of automatically translating Russian; and a divinity scholar used it to produce a concordance of the Bible.

This was Phase 1. As commercial machines moved into universities, most academicians gave up the idea of building their own computers, and computer applications began to spread throughout the campus.

Our second question: What has been the nature of the development of computing in higher education and how has it grown over the years?

Moving into the Big Time

Phase 1 gave way to Phase 2 in 1956. That was the year that IBM bestowed gifts of IBM 704 computers to form university (and also regional) computer centers at M.I.T. and UCLA. It was also the year in which NSF began its Institutional Computing Services program of facilities grants.

During the next eight years computer centers sprouted and grew at colleges and univerisites throughout the country. Phase 2 was the era of second-generation equipment. It was a period of great productivity and expansion, some excellent machines, and the organization of many major university computer centers.

In 1964 IBM announced its upward compatible System 360 line and thus ushered in Phase 3 in this evolution. Other manufacturers soon followed suit with their own models of third-generation computers. The production of operating systems for these computers turned out to be much more costly, time-consuming, and difficult than anyone anticipated, and their efficiency was disappointing (to put it mildly). In addition, most third-generation machines were incompatible with their second-generation predecessors in a software sense, and program libraries had to be extensively redone.

Phase 3, although a period of continuing growth and markedly increasing computing budgets, thus brought with it a great deal of frustration and chagrin. Computer center directorships began to turn over more rapidly, and the number of vacancies for that position became almost as numerous as those for college presidents today. The faculty members who had previously held these directorships started to return to academic pursuits and were replaced by professional managers, many recruited directly from industry.

One of the greatest disappointments during Phase 3 was the failure of large-scale time sharing to meet the expectations held for it at the beginning of the period. Only at M.I.T., where time sharing in the grand manner was conceived, did it prosper and expand. Time sharing on a more limited scale, by contrast, was successfully developed at several places: Dartmouth College, the Rand Corporation, and Berkeley, among them.

Some companies made their computer services directly available to academic users. Colleges and universities also began to form regional systems for sharing their computer resources. These developments ran counter to the do-it-by-and-for-oneself attitude that pervaded Phases 1 and 2, an attitude that was promoted actively by computer salesmen. New and increasing competition and alternatives to using the university computing center were starting to appear.

Another important development during Phase 3 was a significant decrease in cost and increase in power of small computers, reflecting advances made in the application of integrated circuitry. Many users were able to acquire substantial equipment for themselves for the first time, thus reducing their dependence on (and their association with) the main computer center.

Figure 1 shows the growth of computing in higher education during the half dozen years from 1963 to 1969. Annual expenditures rose by a factor of over five during this period, and colleges and universities operating their own computers rose from 200 to over 1,100. Similarly, Figure 2 portrays expenditures by some major individual institutions. But Figures 1 and 2 do not present a complete picture of the growth of computing, since computer technology was on the move and computers were providing significantly more power and capacity per dollar each year. It has been estimated that over the course of these half dozen years the cost of computation was lowered by an order of magnitude even while computing budgets kept growing. Figure 3 makes the point dramatically in the case of Princeton University. Measuring

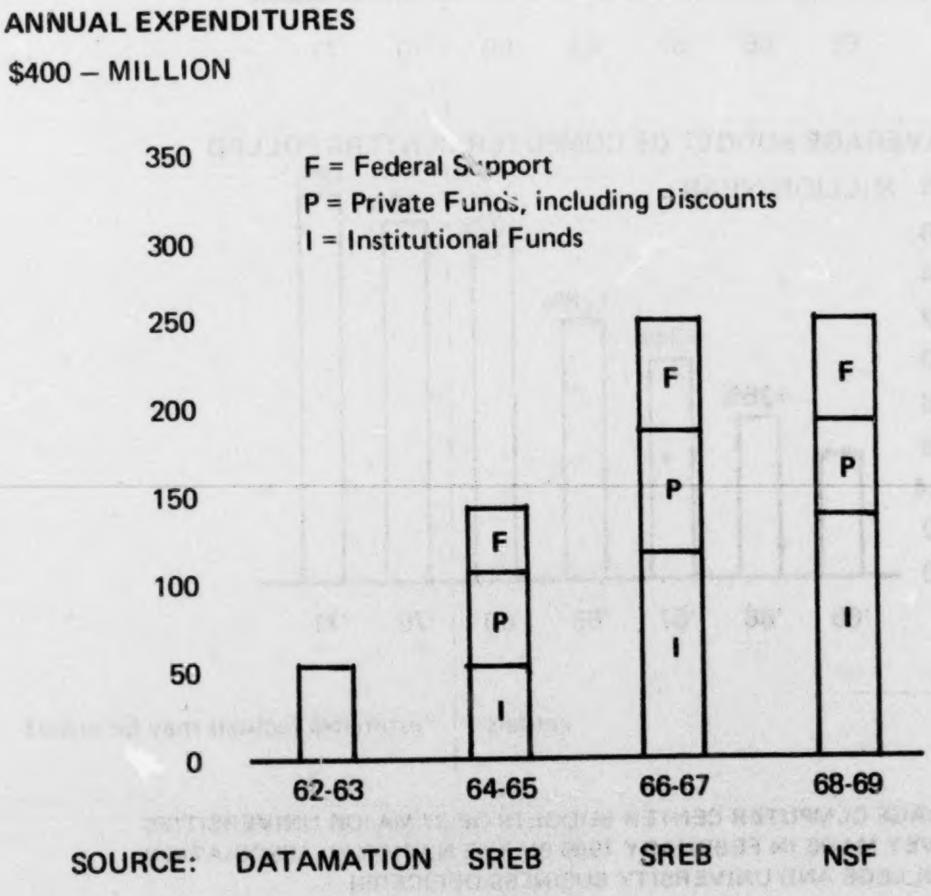
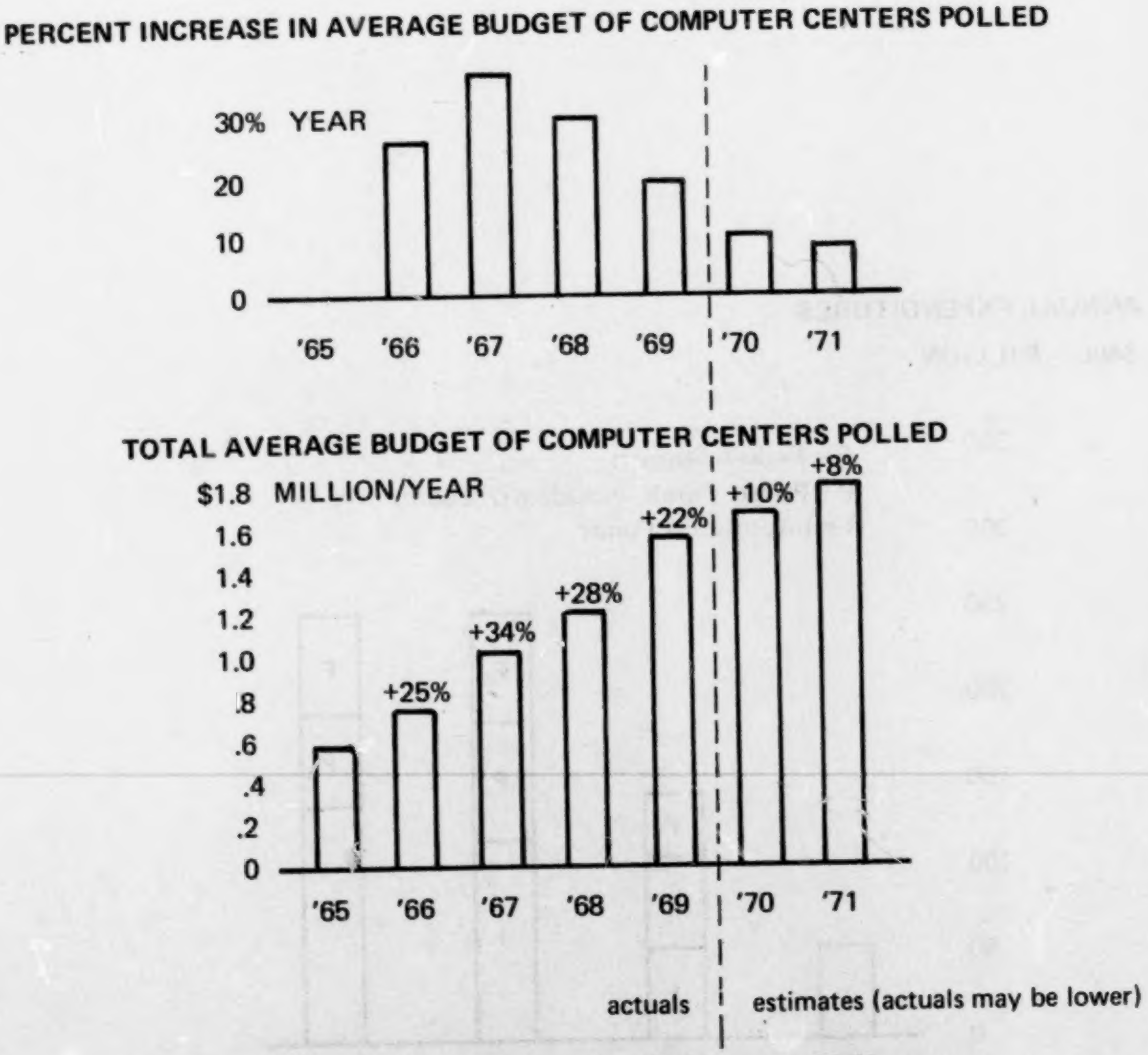


FIGURE 1. GROWTH OF COMPUTING IN HIGHER EDUCATION



PERCENT INCREASE IN AVERAGE BUDGET OF COMPUTER CENTERS POLLED

TOTAL AVERAGE BUDGET OF COMPUTER CENTERS POLLED

FIGURE 2. AVERAGE COMPUTER CENTER BUDGETS OF 37 MAJOR UNIVERSITIES (SURVEY MADE IN FEBRUARY 1969 BY THE NATIONAL ASSOCIATION OF COLLEGE AND UNIVERSITY BUSINESS OFFICERS)

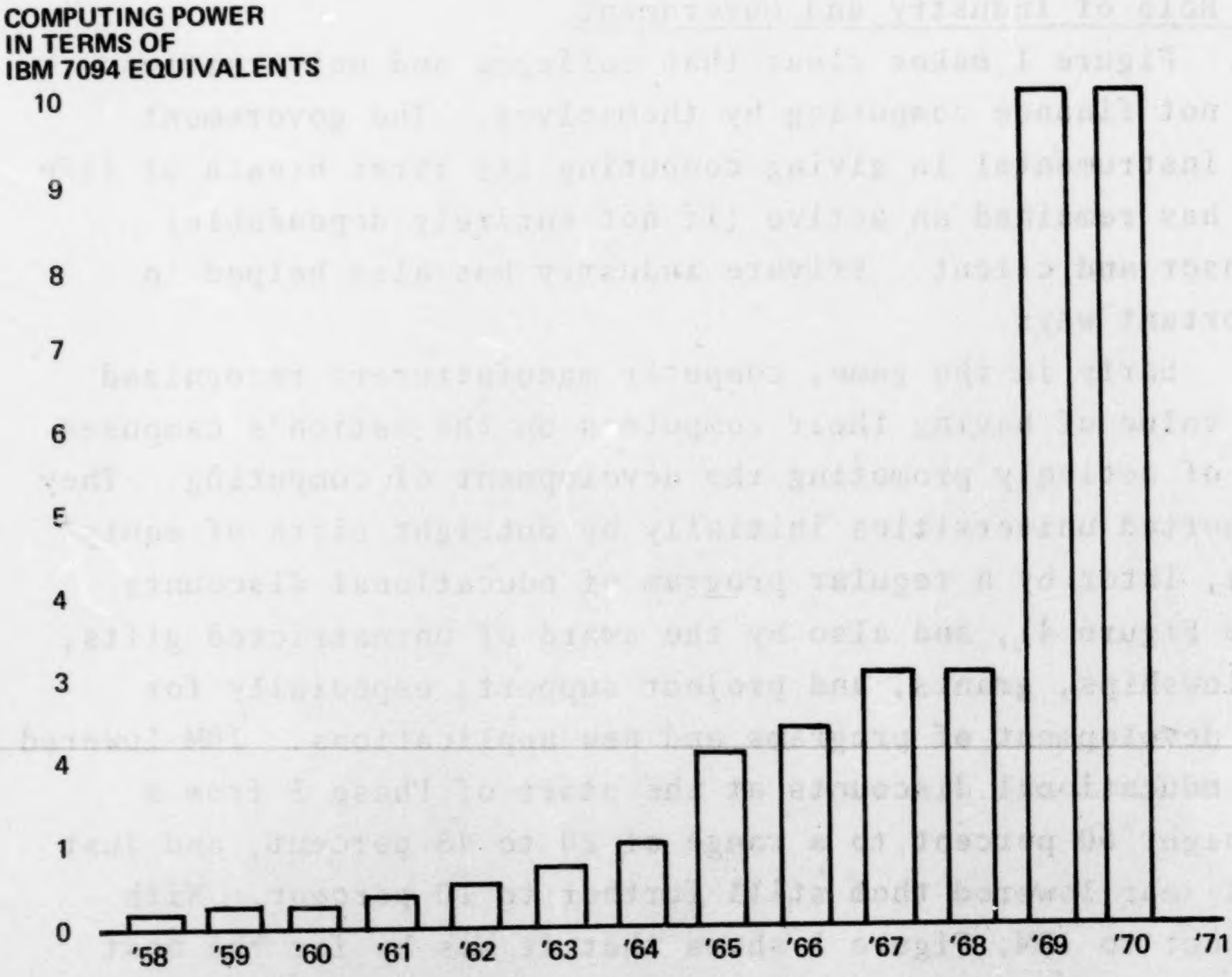


FIGURE 3. GROWTH IN COMPUTING POWER AT PRINCETON UNIVERSITY

computing power in units of IBM 7094 equivalents, the increase in power over the six years works out to about 15-fold at that institution.

A third question: What has been the role of industry and government in the development of computing in higher education?

The Role of Industry and Government

Figure 1 makes clear that colleges and universities did not finance computing by themselves. The government was instrumental in giving computing its first breath of life and has remained an active (if not entirely dependable) sponsor and client. Private industry has also helped in important ways.

Early in the game, computer manufacturers recognized the value of having their computers on the nation's campuses and of actively promoting the development of computing. They supported universities initially by outright gifts of equipment, later by a regular program of educational discounts (see Figure 4), and also by the award of unrestricted gifts, fellowships, grants, and project support, especially for the development of programs and new applications. IBM lowered its educational discounts at the start of Phase 3 from a straight 60 percent to a range of 20 to 45 percent, and just last year lowered them still further to 10 percent. With respect to IBM, Figure 5 shows that it has by far the most computers on college and university campuses, and Figure 6 indicates that its educational customers have tended to be relatively loyal.

A principal reason for the reduction of discounts is antitrust pressure; but there are other reasons too. One is the Carnegie decision of 1964, in which the government ruled that a university receiving an educational contribution on its computer could not apply the full undiscounted cost of the machine as a reimbursable item against government contracts.

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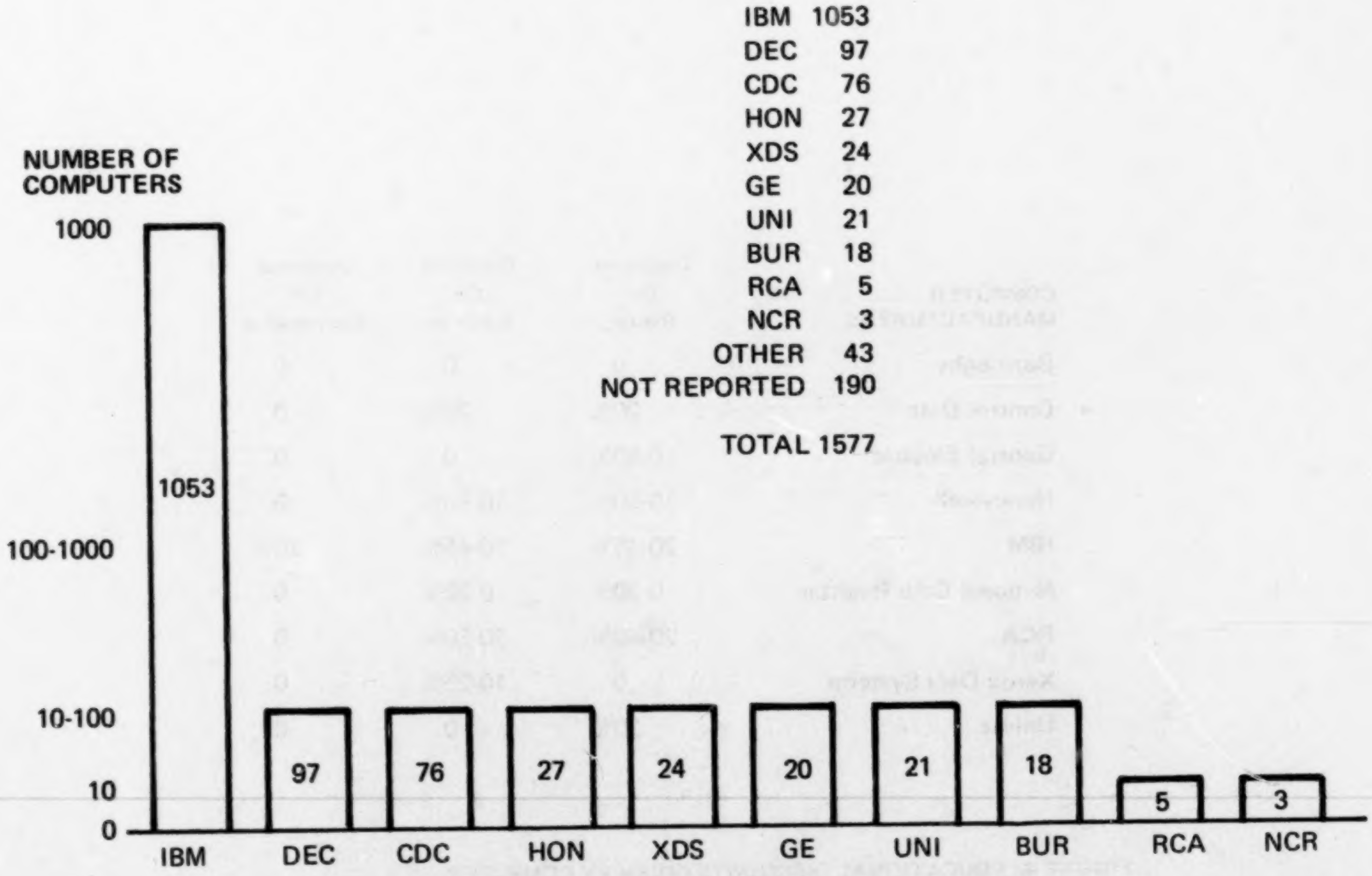
COMPUTER MANUFACTURERS	Discounts On Rental	Discounts On Purchase	Discounts On Maintenance
Burroughs	0	0	0
Control Data	20%	20%	0
General Electric	0-50%	0	0
Honeywell	10-50%	10-50%	0
IBM	20-45%	20-45%	20%
National Cash Register	0-20%	0-20%	0
RCA	20-40%	20-50%	0
Xerox Data Systems	0	10-25%	0
Univac	20%	0	0

FIGURE 4. EDUCATIONAL DISCOUNTS GIVEN BY COMPUTER MANUFACTURERS DURING 1966-1967 (COMPLIED BY WILLIAM SHARPE)



BUR = Burroughs
CDC = Control Data Corporation
DEC = Digital Equipment Corporation
GE = General Electric Corporation
HON = Minneapolis-Honeywell Corporation
NCR = Nation Cash Register
XDS = Xerox Data Systems
UNI = Sperry Rand UNIVAC

FIGURE 5. NUMBER OF COMPUTERS IN HIGHER EDUCATION IN 1965 BY MANUFACTURERS

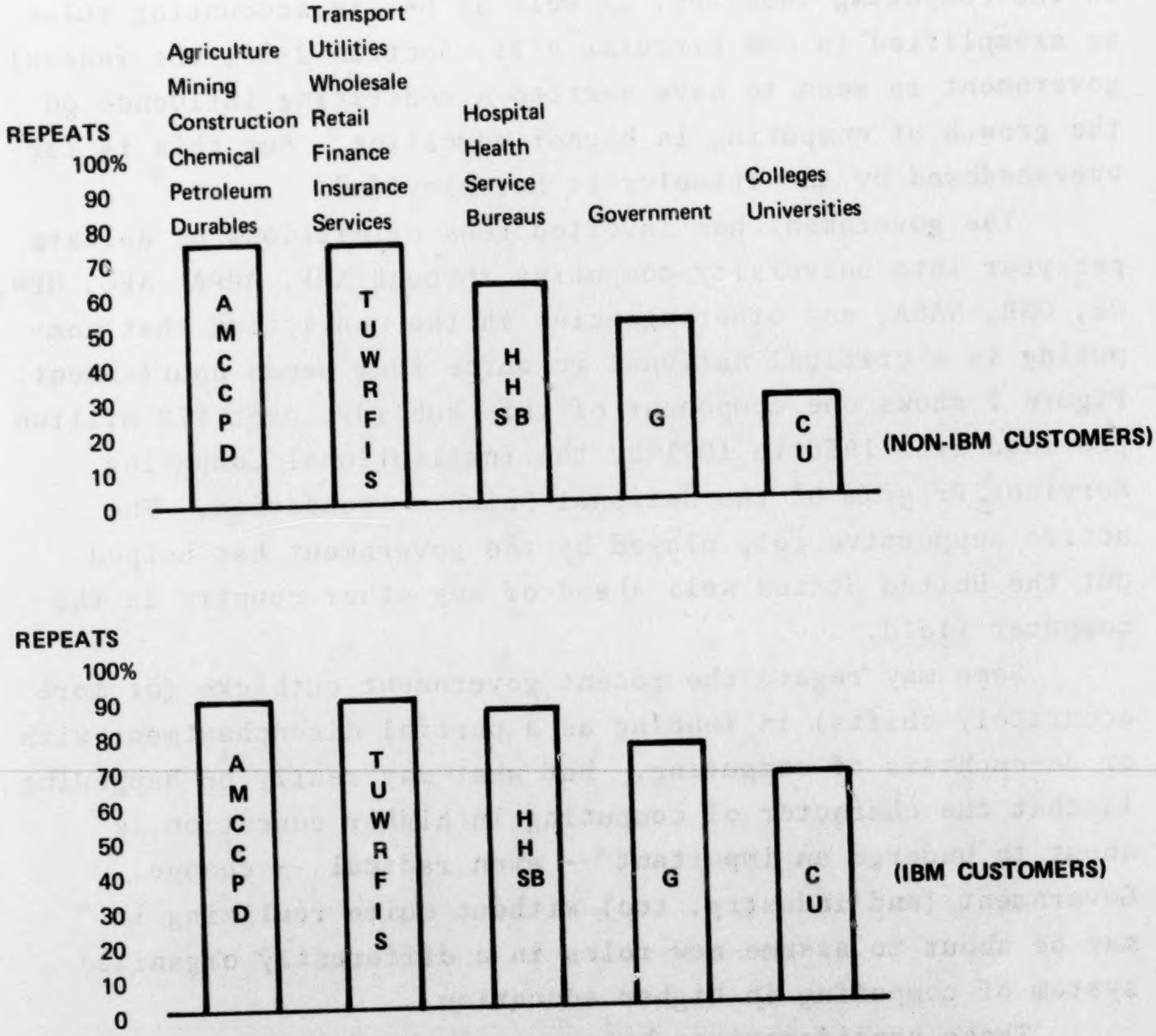


FIGURE 6. CUSTOMER LOYALTY FOR COMPUTER EQUIPMENT OF IBM AND OTHER MANUFACTURERS (% REPEATS) BY INDUSTRY 1970

(SOURCE: EDP INDUSTRY REPORT, MAY 14, 1971)

The contribution must be shared among all users of the computer. Another reason is the fact that current tax laws have become less permissive with respect to charitable deductions.

Because of the effect of its tax and antitrust policies on the computing industry, as well as by its accounting rules as exemplified in OMB Circular A-21, Section J-37, the federal government is seen to have exerted a moderating influence on the growth of computing in higher education. But this is far overshadowed by the stimulus it has provided.

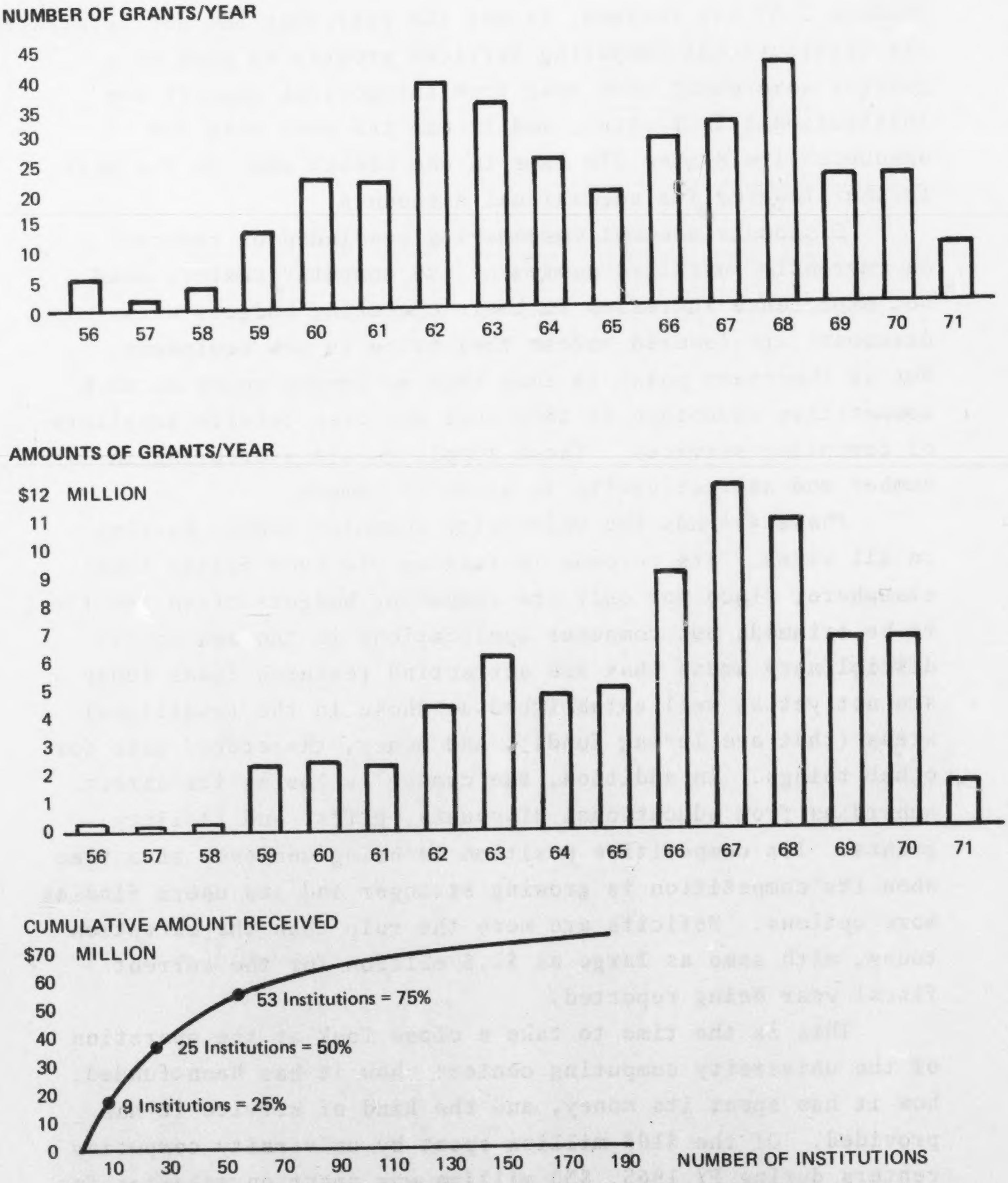
The government has invested tens of millions of dollars per year into university computing through NSF, ARPA, AEC, HEW, OE, ONR, NASA, and other agencies in the conviction that computing is a critical national resource that needs nourishment. Figure 7 shows one component of this subsidy; over $70 million provided from 1956 to 1971 by the Institutional Computing Services Program of the National Science Foundation. The active supportive role played by the government has helped put the United States well ahead of any other country in the computer field.

Some may regard the recent government cutbacks (or more accurately shifts) in funding as a partial disenchantment with or de-emphasis of computing. But what may really be happening is that the character of computing in higher education is about to undergo an important -- even radical -- change. Government (and industry, too) without quite realizing it may be about to assume new roles in a differently organized system of computing in higher education.

These considerations bring us to the fourth, currently pressing, question: What is taking place and where is it leading?

Phase Four

We are presently in the opening stages of Phase 4. The year 1970 marked its beginning. In that financially sobering year, the budget item for computing was often the first place



340 NSF FACILITIES GRANTS FOR FY 1956 THROUGH FY 1971 AMOUNTING TO $72.8 MILLION AND GOING TO 184 INSTITUTIONS IN AMOUNTS OF $5.1 THOUSAND TO $1.5 MILLION

FIGURE 7. NSF INSTITUTIONAL COMPUTING SERVICES PROGRAM (SOURCE: NSF OFFICE OF COMPUTING ACTIVITIES)

one looked for savings. 1970 was the year that Circular A-21, Section J-37 was revised; it was the year that the NSF terminated its Institutional Computing Services program as part of a general government move away from categorical support for institutional facilities; and it was the year that IBM announced its System 370 line in one breath and, in the next, further lowered its educational discounts.

Discounts are not customarily rescinded or reduced on currently installed equipment, so computer centers need not experience increases in their operating budgets when discounts are lowered unless they bring in new equipment. But an important point is that they no longer enjoy as much competitive advantage as they once did over outside suppliers of computing services. These suppliers are increasing in number and attractiveness to users on campus.

Phase 4 finds the university computer center hurting on all sides. Its revenue is falling off even faster than elsewhere, since not only are computing budgets often the first to be trimmed, but computer applications in the new interdisciplinary areas that are attracting research funds today are not yet as well established as those in the traditional areas (that are losing funds), and money, therefore, goes for other things. In addition, the center is losing its direct subsidies from educational discounts, gifts, and facility grants. Its competitive position is being weakened at a time when its competition is growing stronger and its users finding more options. Deficits are more the rule than the exception today, with some as large as $1.5 million for the current fiscal year being reported.

This is the time to take a close look at the operation of the university computing center: how it has been funded, how it has spent its money, and the kind of service it has provided. Of the $103 million spent by university computing centers during FY 1965, $30 million was spent on salaries for about 5000 staff members, and nearly $50 million was spent on buying, renting, and maintaining equipment. Computer manufacturers contributed an additional $41 million in the form of educational discounts and gifts of equipment, bringing the total value of equipment expenditures to over $90 million.

The federal government contributed about $43 million of the $103 million in the form of contracts and grants. Nearly $25 million of these funds were primarily for computing activities with $13 million going for equipment and buildings; $7 million for operation; $3 million for computations in research, development, and graduate instruction; $1.5 million for computer science; and less than $.5 million for undergraduate instruction (what many feel has been the neglected child).

Figure 8 shows the computing center budgets in 1970-71 of sixteen (non-scientifically) selected universities covering a range from $200 thousand to $3.7 million per year. These budgets represent from under 1 percent to almost 4 percent of the total university expenditure for operations, as indicated. In the somewhat larger sample given in Figure 9, the university is seen to contribute from under 20 percent to over 90 percent of the funds for computing, with a peak occurring between 80 and 90 percent. Figure 10 indicates for the same sample that it is the universities with the smaller computing budgets that tend to be the largest percentage contributors to the computing activity. It is probably also true that the smallest percentage contributors are the ones experiencing the largest deficits today.

Now is the time to ask the difficult and searching questions about the present phase in the development of university computing.

1. Will (and should) the university computing center survive in the form it has taken up to now?

2. Will decentralized mini-computers, regional systems, outside commercial services, and national networks

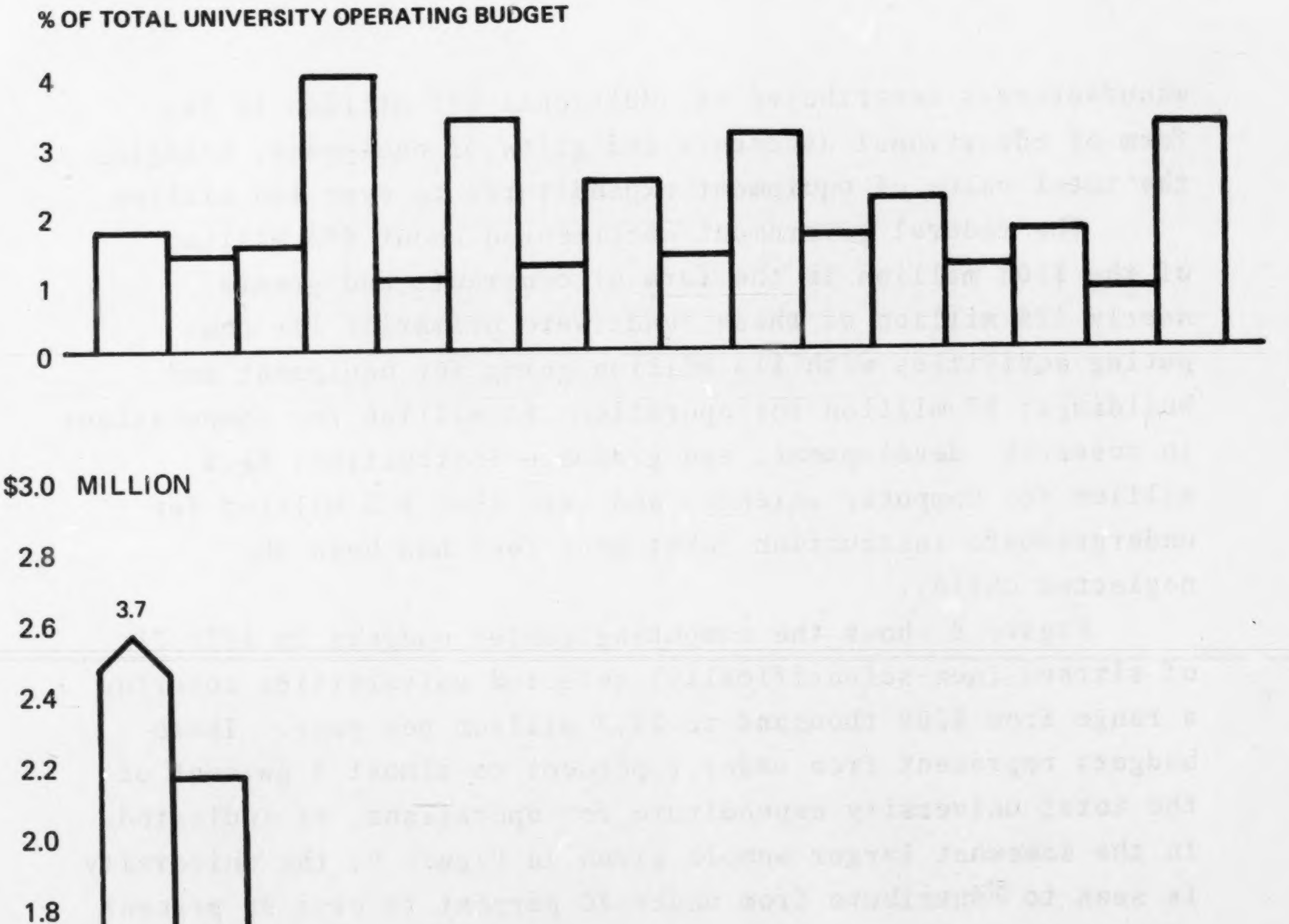


FIGURE 8. COMPUTING CENTER BUDGETS OF 16 UNIVERSITIES, 1970-71
(FROM DATA COMPILED INFORMALLY BY REX KRUEGER)

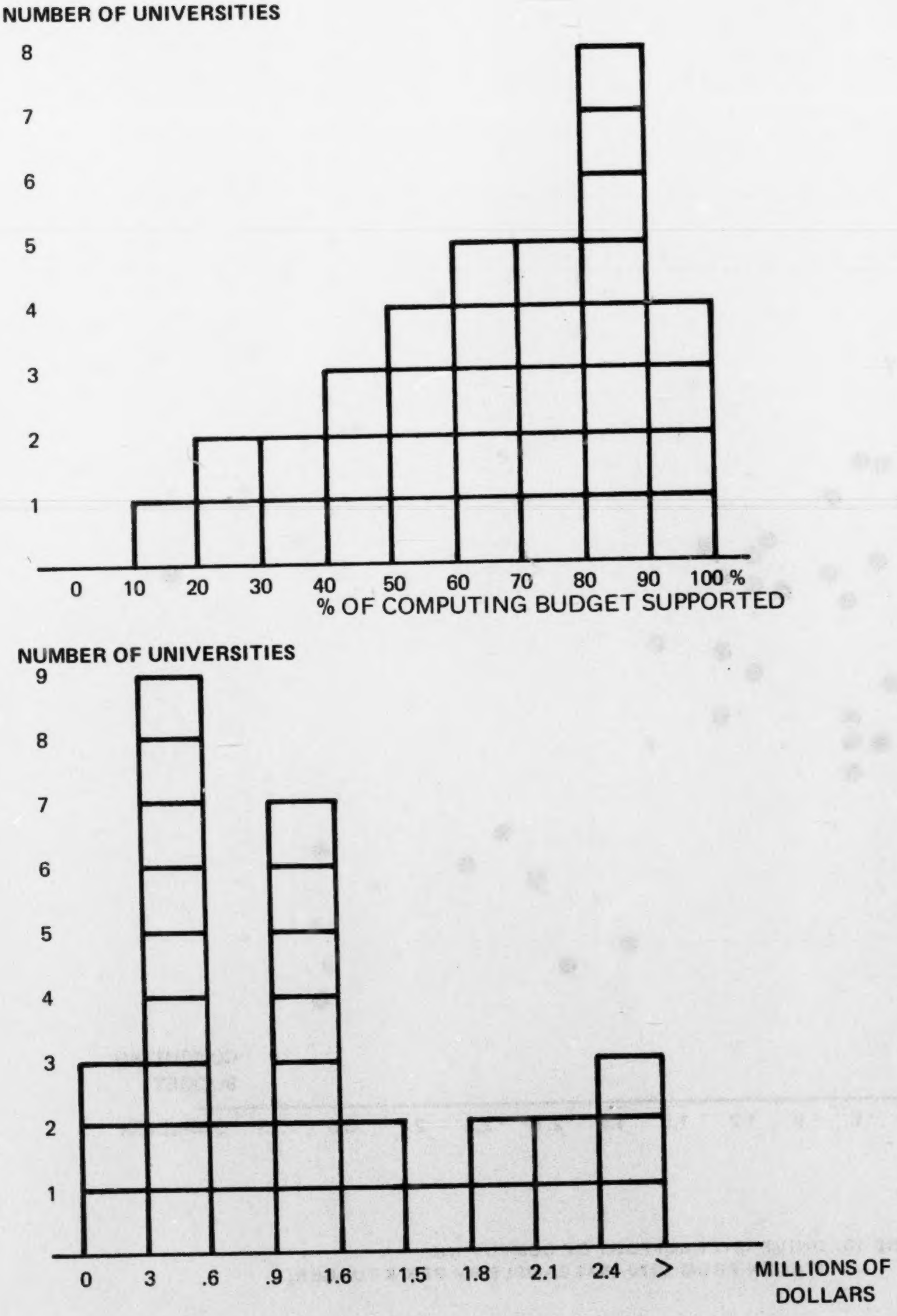


FIGURE 9. UNIVERSITY SUPPORT OF TOTAL COMPUTING BUDGET
(TAKEN FROM 1970-1971 SAMPLE BY REX KRUEGER)

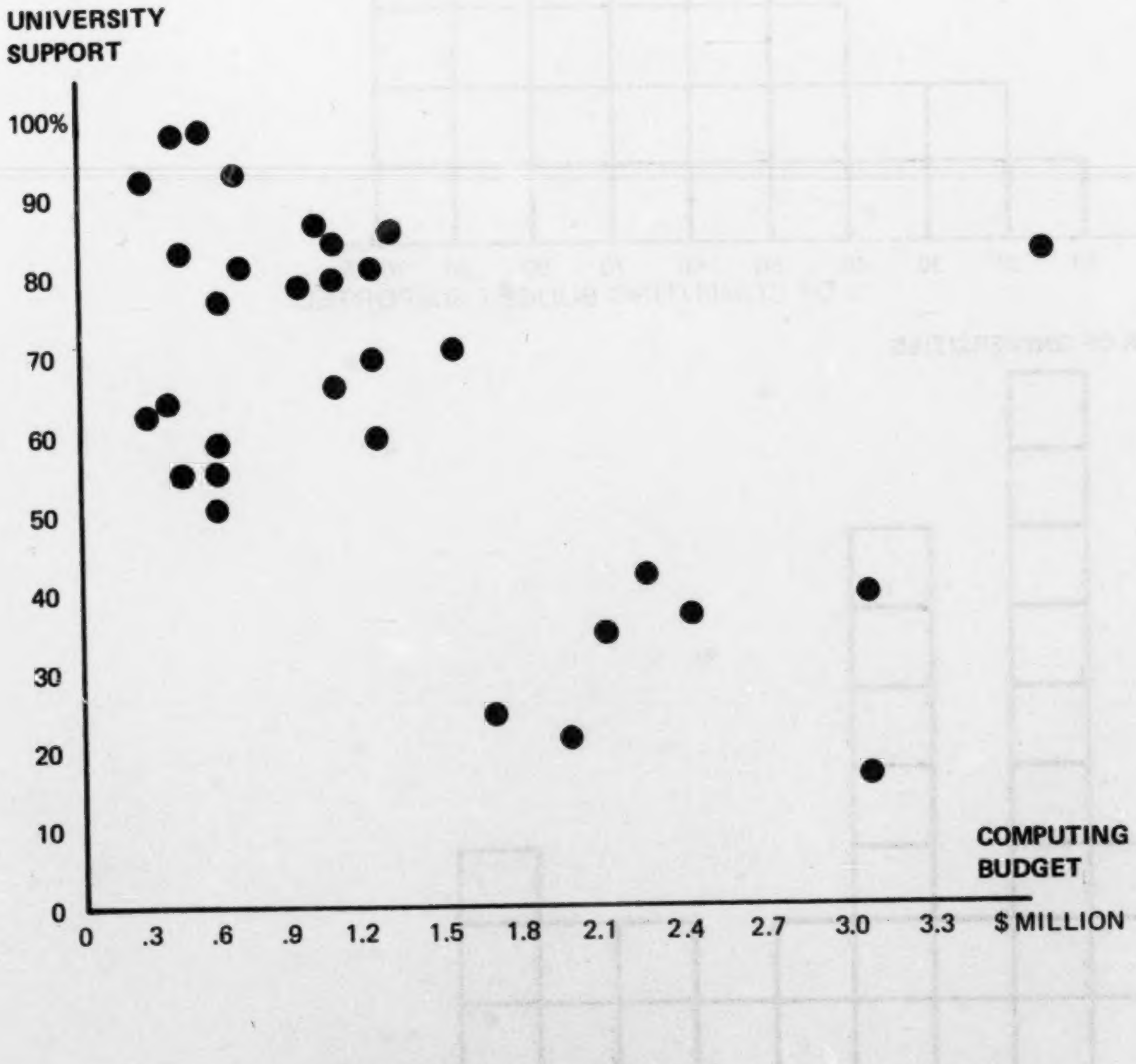


FIGURE 10. UNIVERSITY SUPPORT OF COMPUTING (TAKEN FROM 1970-1971 SAMPLE BY REX KRUEGER)

prosper and grow? If so, where does this leave the computing center?

3. What is the ultimate place of computing in higher education? What part will it have, for example, in undergraduate and secondary school education?

4. What roles (direct or indirect) should government and industry play to promote further healthy development of computing in higher education and to protect this critical national resource?

These questions, among others, are considered in the papers and discussions that follow. How the questions get answered in the months and years ahead will have long-range implications for the future of computing and the future of education.

STATEWIDE PLANNING
AND
REGIONAL CENTERS

ROBERT B. MAUTZ
Chancellor
State University System of Florida

My philosophy with respect to the role of computers in universities is shaped by my experience, and probably the best background for my remarks is to indicate these experiences.

The University of Florida, with which I was associated for 20 years, was one of the earliest universities to utilize electronic data processing machines for administrative purposes. The first effort was made in the registrar's office. The size of the university necessitated rapid mechanical processing of registration information, grades, student grade-point averages, and comparable material. The registrar's office operated under the Vice-President for Academic Affairs. The Vice-President for Business Affairs, who had his office down the hall from the registrar, became aware of the capability of the machines utilized by the registrar and began to build his own machine processing operation.

Thus, when I became Vice-President for Academic Affairs, I found two large, well staffed and well equipped operations at the two ends of the same building. As a member of the university budget committee, I heard the needs of these two units presented without regard to the possibilities of a joint utilization of equipment or personnel. When I inquired into the possibility of such a joint utilization, I discovered that we had established two kingdoms wherein the guardians pled the necessity for independence to achieve service and generally managed to retreat into a jargon which made wise decisions by those dependent upon the service impossible.

At the same time the university had a statistical laboratory that was under the direction of the graduate school and was extensively used by the agricultural branch of the university. This laboratory was basically a processing operation that used card punches, sorters, and tabulators. With the advent of equipment of greater capacity and speed and the upgrading of faculty, it became obvious that the university would soon have to upgrade its facilities and provide a computer center to service its research and instructional efforts. Mindful of the lessons of the registrar and business office, I made a number of decisions that were designed to insure a versatile computer of maximum capacity and service at minimum cost to the university. The major decisions were:

1. The computer was placed under my office and established as an individual administrative entity with a director who reported to me. This administrative arrangement was desirable to insure that any computer would be concerned with the total program of the university rather than emphasizing a single aspect of it, such as the graduate program or a given part of the graduate program.

2. No computers or computer equipment could be purchased without my approval. To advise me in making these decisions, I established a committee chaired by the director of the computer center. In effect, the director exercised veto authority over any acquisition.

3. I established an advisory committee to the director

of the computer center to be concerned with establishing policy for the center. I hoped, thereby, to assure a service and user orientation for the center.

4. The computer center was not permitted to employ a large staff of programmers or systems analysts. It was my belief that programmers had to be part of the staff of specialized users. Only the intimacy and familiarity with the problems which this relationship assured guarantees that the results of any program services the needs of the user.

5. The financing of the computer center was from four sources. The first of these sources was the state, through a direct allocation to the center from my office. The second was a specific federal grant by the National Science Foundation. The third source was departmental budgets, and the fourth was charges to grants and auxiliary enterprises of the university. The ratio between these had to vary, but in no event was the university support to exceed 50 percent, and over the years that ceiling has not been exceeded. This decision again forced the center to a user orientation.

The result of these decisions was, in my opinion, extremely beneficial. The University of Florida now has an IBM 360-65 with 85 remote terminals throughout the university and the state devoted solely to instruction and research. Three of these are medium speed. The computer is saturated, and the combination of numerous remote terminals and saturation indicates a wide and diverse usage. Financing of the computer center has not been a burden to the university. Small computers have not proliferated, and the university has been able to concentrate its resources upon a single computer, which serves the various needs of the university more completely than would several smaller computers.

The undertaking was so successful that the university, with a nudge from others, ordered the registrar and business manager to consolidate their operations. They now have a single computer with remote terminals that handle all the work of the registrar, including registration, and all the work of the business office. I insisted upon standardization of equipment whenever possible in order that program incompatibility would be at a minimum and that backup would be available for the administrative machines in the event the machine was down at a critical time from the standpoint of the university. The administrative computer is an IBM 360-50. In addition, there are a number of special function computers around the campus to perform specific jobs, such as monitoring the nuclear reactor and gathering data for subsequent analysis on the research computer. All of these computers were acquired only after review by the advisory committee to insure that their acquisition would facilitate the university goal of a central computer serving all the needs of the university.

The lessons I carried to my present position, therefore, were that a large machine provided more capacity, more service, more versatility, and that the expense of operating such a machine was less than operating several such machines, each serving a single unit. I also learned from the experience with the registrar and business office that vast economies could be obtained in personnel costs by pooling systems analysts and programmers, but that the user unit had to have some programming capability. Finally, I believe that the user unit should share some of the burden of the cost of operation as a regulatory as well as a funding device.

The University System employs six-year budget projections. The first time I looked at these projections and segregated the computer cost, I was astonished to realize that the various directors of computer centers had plans for acquisition of machines that would have moved the 1969-70 fiscal year hardware cost from $2.8 million to $5.2 million for 1973-74. The personnel cost would have followed the same pattern, moving from slightly over $2 million in 1969-70 to over $5 million in 1973-74. Despite this vast increase in dollar outlay, the computer capacity of each university would not be maximized in terms of hardware or, in the alternative, would it be significantly increased -- there would be idle capacity until such time as the university's demands matched computer capacity. So I inaugurated two programs, which, for convenience sake, can be called computer sharing and system sharing.

System sharing involves the utilization of systems analysts from various universities supplemented by funds from my office; they operate as a team to design various systems and to write the supporting software. The needs are defined by an interinstitutional group of users. The system sharing is in four basic areas: student data system, core fiscal system, payroll/personnel system, and alumni/placement system.

Let us use the student data system as an example of how system sharing operates. Each university had its own student data system. Frequently, the information was not compatible from university to university and was not always internally compatible, i.e., information from the student data system might or might not accommodate the accounting or program budgeting needs. We appointed the Vice-Presidents for Student Affairs as a basic coordinating council and under them had registrars, admissions officers, and other groups. These groups were requested to define their needs. Their needs were then organized by a systems analyst. We used a software company to write the programs, and the results have been nothing short of astonishing.

A single admissions form has replaced 27 forms. The admissions system is up and running at four universities, and by this fall will be in use at our seven operating institutions. By 1972 it will be in operation at our nine institutions. The admissions officers have expressed extreme pleasure over the fact that they now have data not formerly available. The data are compatible and give my office a basis for comparison. We have more information, a better system, less paper work, and, as importantly, we managed this at a cost that represents one-ninth the cost of designing such systems for nine institutions plus another system for the State University System. The data will be kept up-to-date by an annual review, and modifications are desirable. Thus, we have flexibility. In addition, any university may add to the information but may not change the basic data elements or the overall system. We will continue with the program and eventually will have similar operations in all the system sharing areas outlined above.

We have moved into the concept of computer sharing much more slowly. We have installed an IBM 1130 at Florida Technological University in Orlando and at the Florida A & M University in Tallahassee and connected these to the IBM 360-65 at the University of Florida in Gainesville. We have also interactive terminals at the Florida State University in Tallahassee, the University of North Florida in Jacksonville, five GENESYS locations throughout the state, and my office in Tallahassee. The last two terms we have also had remote registration at the Florida Technological University in Orlando from the computer at the University of Florida in Gainesville. I can only report to you that we have a group of highly satisfied customers and that the units which have tried this remote terminal concept are enthusiastic supporters of our plan for additional computer sharing.

We are currently exploring the feasibility of having one or two research computers of the IBM 370-165 type, which will serve all of the universities and my office through remote input-output facilities. In addition, we are thinking of four regional data centers, each serving a cluster of users. These centers would be served by an IBM 370-145 type. We would have remote card readers, punchers, and high speed input-output devices, such as the IBM 2780. These regional administrative or data centers would replace all computers used for administrative purposes on each of our nine campuses. Similarly, the one or two research computers would replace all computers now used for research. The only remaining computers would be highly specialized smaller computers, such as those used to monitor an accelerator or nuclear reactor or used in a multiphasic screening in the medical school. We are struggling with questions of financing and staffing, and in resolving these questions I use as a point of departure my experiences at the University of Florida.

Reaction to the proposal that we consolidate present operations and establish such centers has been highly predictable. Screams of outrage and agony have arisen from some of the user group, principally from the heads of existing dukedoms. These protests constitute a replay of the protests I heard from the business manager and registrar at the University of Florida or the Chairmen of Physics and Chemistry Departments. All, incidentally, now believe in the central computer. I have had one Vice-President argue with me that it was essential that he retain control of the computer which served his university, although he thought it would be quite feasible to upgrade the computer to enable it to serve my office, a second university, and a local junior college. He readily conceded the illogic of his position when it was pointed out to him but did not retreat.

Cold, hard economics plus the success of the systems and computer sharing endeavors we have presently embarked upon will, I predict, force us to a plan similar to that we are now considering. We believe that we can provide a major computer for research and instruction, four computers for administrative purposes, and establish terminals for $1.8 million less than projected for hardware rental by the individual universities. We believe further that a similar reduction in personnel costs will occur. The ultimate question is whether pride, the desire to remain sovereign, and the love of man for the control of his gadgets will prevail over logic and economics. When the universities and the presidents are faced with the fiscal and service option that will be offered to them I am confident of their answer.

REGIONAL COMPUTER UTILITIES FOR UNIVERSITIES

JOHN A. HRONES
Provost for Science and Technology
Case Western Reserve University

Because the computer amplifies the power of man's intellect, it can play an enormously important role in higher education. Already it is a key element in problem solving, direct instruction, preparation of instructional aids, investigation of the learning process, administrative information systems, and the library. Computing power is essential to work in all fields, even though current usage is still heavily concentrated in the sciences, engineering, and fiscal data processing. The computer is an important tool to students, faculty, administration, and support staff. Moreover, since it greatly enhances our ability to deal with complicated systems and problems, it represents an asset that should be available to all in higher education.

However, there are problems that make realization of this goal -- computer service to all in higher education -- extremely difficult. One of the most pressing problems today is: How can the universities finance the computer services they desire and need?

While it is difficult to get an accurate accounting in a given institution of the costs for providing computing services, they may range as high as $800 per student per year.

In numerous institutions, a figure of $100 to $200 per student is not unusual. For schools which led in developing computer services for higher education, costs have ranged from $600 to $800 per student.

Until recently, such costs were met by funds and concessions from the following sources:

1. Capital grants from NSF
2. Concession from machine manufacturers
3. Research grants
4. Current operating funds of the university
5. Contributions from other sources.

Under conditions prevailing for some years, a few institutions with strong information, computer science, and engineering activities commanded such sizable support from NSF, the manufacturers, and research funding agencies that amounts drawn from current operating funds of the university, while of significant and increasing magnitude, were fundable. For other institutions, the problem of funding computer activities has always been a serious one.

Now the financing of computer services has become critical in every college and university. NSF funds for purchase of equipment have been sharply curtailed. Support of research has been curtailed. The growing budget deficits of universities have imperiled the use of current operating funds for computing services. At the same time, a growing understanding of the important role of computing in higher education is rapidly increasing the demand for such services.

Essential computing services can only be supplied if more funds become available and the service supplied per dollar is sharply increased. The environment in which these problems must be solved is different for each institution. Nevertheless, it is convenient to classify them into three groups.

GROUP 1 -- Group 1 includes colleges and universities that have been in the computer game for some time. They are probably spending from $1 million to over $6 million a year in computer-related activities. They probably own or lease a large third-generation computer and likely have a number of smaller installations in operation.

GROUP 2 -- Group 2 includes a number of medium-to-large-sized institutions of higher learning (5,000 students or more) which have no great strength in the information and computing sciences. They have limited research programs, little operating experience as far as computing centers go, and may own or lease intermediate size equipment.

GROUP 3 -- Group 3 includes a large number of relatively small institutions that have no experience in the operation of a computer of any substantial size. However, they may own or lease a small computer primarily for routine data-processing tasks and may be linked to a larger institution with more adequate computing facilities.

Across these groups, there are problems common to most institutions: the problem of sufficient machine capacity, of diversity in the backgrounds and interests of users, of reluctance by users to pay for services, and of users who want their own computing equipment. Such problems are intensified by the current financing squeeze. It is clear that their solution will require a large national effort over a significant period of time.

It is also clear that it is difficult to generalize about solutions so, with the hope that our experiences in the Cleveland area with Chi Corporation will be of interest, I shall try to briefly describe the development and financing of computing operations at Case Western Reserve University.

In 1965, Case Institute of Technology launched a study of how it might meet its growing demands for additional computing services. At that time Case had in operation a large configuration UNIVAC 1107. We had designed our own executive operating system, which provided a batch operation with very fast turnaround time. The computing center served approximately 2,000 users, and the 1107 was also the equipment with which the computing sciences group carried on research and development.

This 1107, one of the large, fast machines of its time, was financed from three sources: a relatively large grant from the National Science Foundation; borrowing from certain university funds restricted for that general purpose; and from services rendered to one interested corporation.

Relatively early in its work, the committee was able to recommend a category of computing equipment which involved, regardless of the manufacturer selected, an investment of between $3 and $5 million. While the problems of machine selection were difficult and involved, the hardest problem was to find a way to finance getting the equipment. The picture looked bleak for several reasons: our estimate of the demands upon federal funds for such purposes and the funds that were apt to be available, the changing relationships between the manufacturers of large computing machines and universities, and the lack of availability of operating funds at the projected level required by the new equipment. Hence, we concluded that the funding methods which had worked so well up to that time would not likely succeed for many years longer.

In searching for a solution to the situation, a number of models were conceived. The one which seemed most promising was a profit-making corporation in which the university would be a part or full owner. The executive committee of the Board of Trustees was interested in the idea and retained a management consultant to investigate the matter further. The resulting report supported the idea and in early 1968 Chi Corporation was launched.

Chi Corporation is incorporated in the state of Ohio as a profit-making corporation for the purposes of providing computing services to Case Western Reserve University, to other educational institutions, and to industrial and governmental organizations. A large configuration UNIVAC 1108 was purchased, and the university contracted with Chi Corporation for its computing services for a period of four years. In addition, Chi Corporation was able to negotiate a relatively large three-year research and development contract with an industrial organization. Then, on the basis of these contracts, Chi was able to borrow the money required to purchase its computing equipment.

Chi Corporation has a separate board, with half of the directors being interested industrialists and the remaining half having some connection with the university. In appraising the resources upon which Chi Corporation could be built, it was recognized that because of the university's history in computing we had an extremely competent group of both hardware and software people who, although young in age, had a great deal of successful experience in the operation of a large computing center. For many of these people the framework of Chi Corporation broadened the horizons of opportunities.

At the same time that we recognized these very important strengths in existence and available to Chi, we recognized that few, if any, of our people had the experience and know-how in sales and in the management of a profit-making organization. Therefore, we sought for a president who would bring to the company this much needed talent. This is not an easy post to fill as the president of Chi Corporation must be sensitive to the unusual and diverse demands of the university, which is always going to be a large customer, but at the same time he must be sensitive to a wide range of industrial customers with differing needs.

At the same time that Chi Corporation was set up, the Jennings Computing Center, which is the University Computing

Center, was strengthened in two ways. First, a new director, Professor Glaser, was brought in. Secondly, the decision was made to provide the Jennings Computing Center with research equipment, largely for the use of the information and computing science staff and students. For this purpose, a large configuration PDP/10 was brought in. Thus, the main body of research in the information and computing sciences was remove from the large scale general purpose UNIVAC 1108. The Director of the Jennings Computing Center is also responsible for the university's relationships with Chi Corporation, including operation maintenance and educational policy questions.

How does the operation look three years downstream? One might comment that the task has been much more difficult than we anticipated. However, the operations of the company have come quite close to the predictions made prior to its founding. At the present time Chi Corporation employs about 80 people. It has about 150 customers. Three of these are other educational institutions. Its operations are running at a level of nearly $2 million a year. The company should reach the breakeven point this month (April 1971), and we expect it to build surpluses that will begin to reduce an accumulated deficit of substantial magnitude.

We have learned a great deal about the operation of a large scale computing center, and we believe the basic premises upon which this company is established are sound. We believe that similar operations in other carefully chosen locations can prove to be very successful, particularly if a close working relationship between two or more such operations is developed. Chi Corporation stands ready to assist in such undertakings.

REMARKS FOLLOWING PRESENTATIONS BY DRS. GREENBERGER, HRONES, AND MAUTZ

DR. SCHATZ:

I would like to change the tone a little bit and give you a senior officer's view, at an institution where the computing is supposed to be pretty good. Listening to Mr. Greenberger, I couldn't help but think about the history of computing at our institution. I'll take you from the beginning to the end very quickly. In the early 1950's Carnegie Tech was offered a computer being built by the Mellon Institute, with which we later merged. It was only partly finished and they wanted to give it to us for one dollar. We turned them down, not because the price was too high and not because it wasn't finished but because we weren't sure we needed a digital computer. Two years later, we got our first digital computer, an IBM 650, and things have gone downhill from that point on.

When my fellow vice presidents or provosts at other institutions now ask me what computer system we have, my answer is we have one of every kind. We have two PDP-10's, many PDP-8's, one UNIVAC 1108, one IBM 360/67, one Sigma Five, one Burroughs 2500, one hybrid which happens to be connected to the 360, and a number of other small machines.

I have been the Vice President for Academic Affairs for about seven years and the Director of the Computer Center has reported to me all that time. My view of what computing has been like on our campus for those seven years is hard to describe. I have not yet seen a fully satisfied customer, not even the people who designed the system. It's been expensive and chaotic, but there are some signs of change on our campus and I would like to indicate what those are.

Until July 1970 our computer center was the captive of our Computer Science Department. Somewhere in the 69-70 school year, divorce proceedings were instituted and the Computer Science Department and

and the computer center decided to accomplish that divorce on July 1, 1970. As with most divorces there was a great deal of wrangling over the custody of the children, the children being computers and programmers and engineering people of all kinds, and I might add that the custody problem has not yet been completely solved.

When our Computer Science Department and computer center were divorced, we were faced with the question of what to do with our two major computers, the 1108 and the 360, one of which (the 1108) we owned and one of which (the 360) we rented. Our university computing council wrangled over the matter for a long time; finally we decided to rent the 360 for at least another year. About six months ago it became clear from my office that we could no longer afford to rent that computer; we either had to get rid of it or we had to own it. So I posed the question: Should we buy the 360 or should we get rid of it and put something else in? The campus was evenly divided on the question. It finally came to a meeting of the computer council and because there were seventeen members on the council, I felt very sure that I would get an answer. We discussed the matter and at the end of the meeting I asked each person to simply answer the question on a piece of paper. I have never revealed to this day how those seventeen pieces of paper came out but I will let you in on it now. Eight people said we should buy, eight people said we should not, and one person said he couldn't make up his mind. We decided to buy the computer. _I_ decided that we would buy the computer.

In spite of what I have told you, we have at this moment a very fine operating computer center. We have just come through the spring rush on our campus. All PhD candidates do their computing on our campus in the month of April, and it is April 29th; the computer center director is in the first row, his associate's in the first row, and I'm here, and we could only be here if things were fine back in Pittsburgh.

After seven years, we have managed, through a process of decision and management, to get some control over the situation. We've gotten our operating costs down tremendously. We are operating at a ratio of one operations dollar to three hardware dollars. And we haven't done this by just pushing down the operating costs.

DR. PATTERSON:

I only have two comments: First, I admire Dr. Mautz's courage. We are in a similar process on a smaller scale. Second, I think he will soon face something that Dr. Hrones has already faced in very realistic terms, providing special computers for special users. A school that's strong in life sciences and medical research is going to have a bit of trouble with his type of organization. I suspect that he too at some point will find a proliferation of purchase orders for smaller and then larger PDP-8's, PDP-12's, PDP-10's, Sigma 6's, Sigma 9's. I think that Case Western has faced this very realistically. I'd like to ask Dr. Hrones a specific question: As you look back, what do you feel is the necessary balance between educational and commercial income for doing this? I think many of us are interested in this type of situation, you might be able to give us some guidelines.

DR. HRONES:

The purpose of an operation such as Chi Corporation is to try and bring dollars into the university orbit that ordinarily would not be in the university orbit; so that you want a substantial amount of commercial business. In our initial projection, we had planned that at full maturity, the university business would constitute about one third, and the balance would be commercial. There is one other comment I ought to make, the kinds of arrangements with industrial companies and universities are the same. If an industrial company will write the same kind of contract for the same volume, mix and calibre of work as the university, it will get the same rates as the university. At the present time, the university's contract with Chi is a large one and a long range one so that its rate is substantially lower than any other customer's. But there will be a customer, developed to that scale within the next year or so.

II SPECIAL TOPICS

Special Topic 1: CENTRAL COMPUTING

Chairman: ROBERT GILLESPIE
Director of Computer Center
University of Washington

JAMES POAGE
Director of Computer Center
Princeton University

NORMAN ZACHARY
Director of Computing Center
Harvard University

Robert Gillespie opened the session by enunciating two classes of problems as topics of discussion: those concerned with the critical issue of financing, and those involved in the search for alternative strategies for operating computing centers. How do we want the centralized computing facility to develop over the next few years? Can we assume that there will be the same kind of growth there has been in the past? How should policies dealing with small computers be formulated? To what extent can one find ways of avoiding the continuous upping of the ante for the support of computing facilities?

Funding

James Poage began the discussion by presenting figures describing the computing situation at Princeton. Without claiming them to be representative, he suggested that some specific numbers would be a good starting point. The total Princeton budget, in terms both of dollars and relative percentages, is shown in figures 1 and 2.

Some other, comparable figures were presented. At the University of Washington, the Computer Center budget is $1.3

million. In addition, there is a systems analysis staff (for administrative application) that is responsible to a financial vice-president and is not part of the Center at all. At Harvard (see figure 3), the academic computing budget seems significantly lower than that at Princeton. However, there are several factors to be considered. In particular, externally funded projects are not required to use the Computing Center and there are therefore a number of smaller computers scattered across the University.

Gillespie reported on a survey he has taken of a number of large computer centers; the average budget of those surveyed was in the neighborhood of $2 to $2.4 million. This is for academic computing only and includes people and services as well as hardware cost. The range in the actual numbers was fairly wide; the University of Washington was low, spending only $1.3 million for academic computing.

Of course, differences in budgeting technique make detailed comparisons difficult. In Gillespie's analysis, he converted most of the hardware costs into approximate rental value in order to overcome this difficulty.

Several speakers cited the difficulties of definition, which make it hard to draw accurate comparisons among figures at different institutions. What, for instance, does "academic computing" consist of -- educational computing for undergraduates or everything that is done by students and faculty? Some institutions amortize equipment purchases over a period of years. Some, such as Western Michigan University, pay for it directly out of state funds. There are some universities in which the computer center is expected to support itself by generating income. At others, computing is budgetted and paid directly out of general funds.

Further, there are alternative ways of handling an NSF facilities grant, which have different effects on the budget. At Princeton, 1/3 of the 3 year grant appears each year as an income item. (See figure 2). At Northwestern University, $500,000 of their facilities grant was deducted from the cost

PRINCETON UNIVERSITY

INCOME vs EXPENSE

1969-1970

INCOME (Thousands of dollars)		
Endowment	$ 9,183	12.5%
Student Fees	11,759	10.0%
Gifts & Grants	6,391	8.7%
U. S. Govt.	28,311	38.5%
Other	2,553	3.5%
Auxiliary Activities	7,491	10.2%
Student Aid	7,776	10.6%
Total	$ 73,464	100.0%

EXPENSES (Thousands of dollars)		
Academic Departments	$ 36,683	49.2%
Academic Computing	2,196	3.0%
Academic Administration	3,514	4.7%
Library	3,214	4.3%
Ed. Plant Maint.	6,533	8.8%
General Administration	3,026	4.0%
Administrative Computing	466	0.7%
Auxiliary Activities	10,186	13.7%
Student Aid	8,631	11.6%
Total	$ 74,449	100.0%

FIGURE 1

PRINCETON UNIVERSITY COMPUTER CENTER

INCOME vs EXPENSE

1970-1971

INCOME (Thousands of dollars)		
NSF Grant	$ 400.0	16.8%
Hardware Rental	92.2	3.9%
Large Sponsored Projects	745.0	31.3%
Small Sponsored Projects	300.0	12.6%
Outside Projects	100.0	4.2%
University General Funds	742.3	31.2%
	$2379.5	100.0%

EXPENSES (Thousands of dollars)		
Salaries/Benefits	596.1	25.1%
Office/Travel/General	31.7	1.3%
Equip. Maint.	188.7	7.9%
Equip. Rental/Amortization	1215.7	51.1%
Computer Supplies/SE	140.4	5.9%
LDS-1 System	50.0	2.1%
Overhead	156.9	6.6%
	$2379.5	100.0%

FIGURE 2

of the computer, thus the grant doesn't appear in the budget at all -- the computer simply appears cheaper and the amortization figures are lower. It would appear that the Princeton method is more indicative of the true state of affairs; however, the budget is increased considerably for three years, after which income is suddenly and sharply reduced.

The Princeton figures, as shown in figures 1 and 2, indicate 3% of the university budget is for academic computing. This is unusually high, in comparison with other figures that have been quoted. However, the machine (a 360/91) is very large, much larger, in fact, than the University really needs. Thus it attracts some large research efforts (the "large sponsored projects" of figure 2) which inflate the figures.

Student Costs

A better way of stating costs may be in terms of dollars per student. In Gillespie's survey, these figures ranged from $40 to $300.

A figure of $20 per student has been quoted for the average junior college. The Pierce report recommended $60 per year as an undergraduate cost, based largely on the Dartmouth experience. The average cost of undergraduate computing at the University of Washington is about $10; this compares with a library cost of about $50 per undergraduate. (This figure is difficult to compute, and a number of assumptions must be made; basically, however, it is the percentage of the cost of the operation of the center that can be attributed to undergraduate use divided by the total number of undergraduates.)

Comparable figures for Purdue University were estimated roughly to be $7.50. A figure was given for Princeton of $70, for the 20% of the undergraduates that are actually *using* the computer. The figures for the entire student body would be $14.

According to an SREB survey, average costs across a wide spectrum of institutions are as follows: 2% of total budget for computing; 3% for libraries; average cost for students actually using the computer, $20. Even these figures, however, may not be totally meaningful. Some programs in an institution (in engineering or management) make very heavy use of computation; the humanities, by contrast, use little or none. Finally, it may be suggested that, in talking about numbers like these, one is going around the essential problem, which is the projection of needs, in terms of what is to be achieved, rather than in terms of hardware or dollars.

Financial problems differ considerably in institutions, depending on the nature of the funding. Many universities, for instance, have an income picture more or less like the diagram on the left in Figure 3. A few institutions - Princeton and perhaps a dozen other universities, have one like the diagram on the right. The institution heavily involved in contracts and grants faces a serious crisis when there is a strong decrease in grants and contract income.

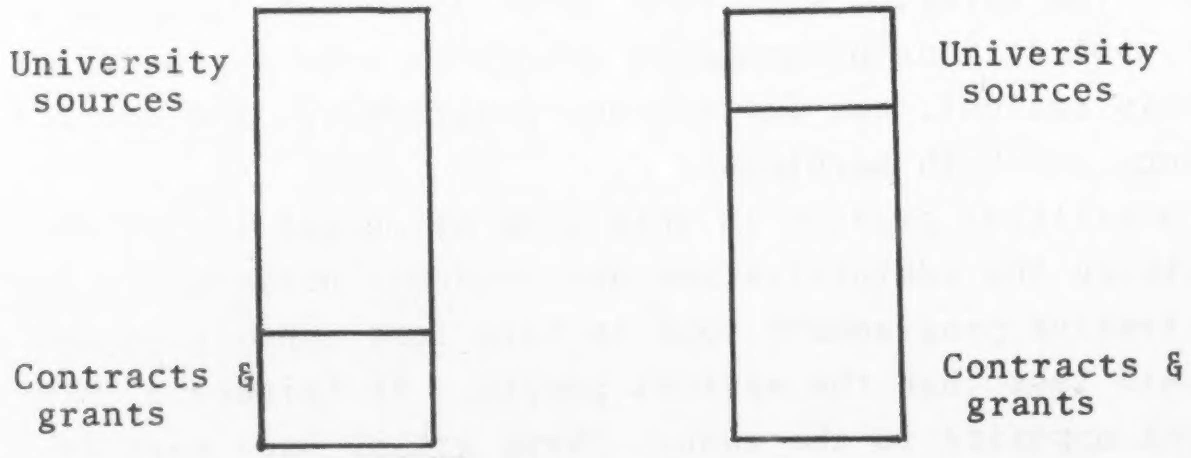


Figure 3

Academic and Adminstrative Computing

Discussions of how it is possible to cut expenses in the computer center often end up with no ideas more serious than reducing the number of pages of paper used, or charging for the use of punchcards. The one major alternative that can be suggested is the merging of facilities on the campus. At Stanford, for example, about $8 million of their approximately $140 million budget is spent on computing. However, only $2 million of this is in the central computer. They recently went through a rather elaborate study of their facilities to see what savings could be achieved through merger. They decided that this was very fertile ground to work with.

At Princeton, a merger of academic and administrative computing is now taking place. The organizational merger has already taken place; efforts are currently under way to combine the hardware into a single installation and a single machine. No staggering savings are to be expected from this merger; however, it should result in a savings of about $250,000 in a couple of years and so is definitely worth considering.

Organization

In making this change, the "Director of the Computer Center" will change his title to the "Director of University Computing" and will probably report to the Provost, a university-wide officer with both administrative and academic authority. The Director will have three Assistant Directors, one for applications programming (which is used exclusively by administration), one for systems programming, and one for operations (of both machines).

A critical problem in this kind of merger is the friction between the administrative and academic personnel. The administrative programmers tend to have less experience and to be paid less than the systems people. At Princeton, however, the opposite is the case. There are no easy ways to evolve policies in this matter.

At Princeton, academic users are expected to do their own programming. Poage felt that, if his budget would permit it, it would be valuable to have such an applications staff for academic users. Such a staff could serve as consultants to potential users who lacked the skills to solve their own problems. If there were such a service available, Poage suggested, there might be a heavier use, or a use of the center by a greater percentage of the students. It may not be the job of the computer center to sell computing to the largest possible number of customers on campus, but it should encourage its use by those who could profit from it.

The solution to this problem at Johns Hopkins is to have a "computer liaison service," staffed by graduate students in various disciplines. They spend part of their time at the center, where they can answer questions and serve as advisors, part back in their own departments, and part doing their own computer related work.

Harvard

Norman Zachary presented a review of the finances and general computer organization at Harvard. There is no line item in the Harvard budget for "computing" so that it is not possible to total all of the scattered resources. However, a list like the one in Figure 4 can be made up, although it does not include a number of smaller computers dedicated to specific research projects.

The University-wide budget is approximately 150 million. Of this, about one-third is from endowment, one-third from student fees, and one-third from grants and contracts. The library system has a budget of $9 million per year. Except for a small ($100,000) grant, this is almost exclusively endowment money. There are no student fees associated with the library; it has always been agreed by all that the library is a generally available university facility. The Computing Center, however, is seen in a totally different light. There is no such concept of universal availability, of being a university-wide resource; nor is there any endowment associated with the Computing Center. A potential user can gain access to the computer by getting a grant or contract or by using departmental funds to buy computer time.

The Harvard Center has had a budget deficit of about $500,000 per year, which is, in effect, the University contribution. It is a very inefficient way of making a contribution since the University does not buy any computing with it. The budget for the current year is intended to break even. In order to do this, the Center has returned machines, reduced the level of service, and permitted an increase in turnaround time.

HARVARD COMPUTING BUDGET:

Academic computing	1,000,000
Administrative computing (at the academic center)	300,000
TOTAL COMPUTING CENTER BUDGET:	1,300,000
Administrative computing and programming (in Comptroller's office)	400,000
Outside timesharing services	250,000
Applications programming group	700,000

BREAKDOWN OF ACADEMIC COMPUTING

Grants and contracts	650,000
Business School	100,000
Associated Hospitals	100,000
Other University users	100,000
Other colleges and universities	50,000

FIGURE 4

To describe how Harvard's computing money is used, one must look at it school by school. The Business School, in its MBA program, is a very heavy user. It spends $250 per student. The undergraduate use is about $20 per student. Other schools use very little -- close to zero. The source of the $1 million academic computing budget is also shown in figure 3.

The staff for the Harvard center numbers about 45 people, including five or six people in a "programming assistance group" -- very similar in makeup and function to the "computer liaison service" at Johns Hopkins. The applications group has 10 administrative specialists and about 25 for general academic computing; most of these latter are associated with medical research. As indicated in the budget, The Harvard Computing Center is used extensively by the Associated Hospitals. The hospitals are getting more and more into computing but (unlike some academic departments) they cannot supply all of their needed programming support themselves.

Administrative Computing

Somewhat like Princeton, Harvard's Computing Center recently became involved in administrative applications. Three or four years ago, it was asked to become involved by administrative departments. Many administrators could not get the support they needed from the comptroller's office; others had attempted to build their own applications staffs and had failed; others went outside the University and bought packages that did not work.

In response to these problems, the computer center established an administrative applications group for administrative users. Some outside packages and services are bought and some programs are written internally, but all projects are under the direction of the applications programming staff.

General Organization at Harvard

The Computing Center Director reports to a committee, consisting of a number of deans and the Administrative Vice

President of the University. Each of the deans considers it his function to be sure his school gets minimum price and maximum service from the Computing Center. The committee has no fixed responsibility and no chairman, creating considerable difficulties for the Center. For example, it was necessary this year to cut down severely on the services offered in order to balance the budget, but since each of these services was important to some dean, it was very difficult to reach consensus on what to cut.

Harvard is attempting a scheme called "forward contracting." Although it hasn't worked in the first year of its use, there are hopes that it will work this year. Each of the deans is asked to come up with a pre-commitment to meet the predicted budget. Last year, the budget was $2 million and the commitment of the deans was only $1.4 million; this explains the deficit. By cutting the budget to what the customers are willing to commit themselves to buy, a break-even condition may be reached.

Zachary believes it is important to have budgets approved by the individual responsive units before they become effective -- not only in the case of expense budgets, as is normally done, but for income budgets as well, so that the customers can see what it is that they are being expected to spend.

A general comment was made that, although the problems that had been brought out in the context of Princeton and Harvard were typical, other problems exist. Despite the drive for consolidation, some people do need bigger machines than those available at the computer center; there are needs for large scale data bases and for more interactive, conversational capabilities. The university may have to acknowledge that up to 20% of the computing budget will be spent off campus.

Northwestern

The situation at Northwestern University is different from that at Harvard and Princeton. The Northwestern academic computer budget is just about $1 million. Of this, $700,000 is from general university funds; $300,000 is from grants and contracts. The $700,000 is a number the university has committed itself to for support of academic computing. The $700,000 is distributed to the deans of the various schools and to the director of research; they further allocate to users in their schools. The primary allocation (to the deans) is made by the Policy Committee, largely on the basis of historical precedence. About half goes to the Director of Research who assigns computer money to unsponsored research projects.

The involvement of the Director of Research is due to a particular problem that has occurred in the past. Although $300,000 was tagged for computing in the grants and contracts in hand, only about $120,000 of it was actually being spent in the Computing Center. The rest went to travel, more graduate assistants, and so on. Since the faculty members were able to get computing from the University budget, they simply did not spend their contract money for computation. In order to try to recover more of these funds, the Director of Research now sees to it that contracted research pays for what it uses from contract funds.

Once a university decides to commit funds to computing, it faces the problem of allocation. Most people allocate in terms of dollars. The Northwestern system uses what is sometimes called "funny money," money which can only be used for computing from the campus computer center.

This affects the behavior of the Center management which expends more effort to get the grants and contracts money in addition to the university funds that are already commmitted.

User Needs and Committees

The final topic of the discussion was techniques for identifying and coordinating user needs and interests. The principle method is the use of various kinds of user groups and committees. At one institution, a policy committee is made up of deans and vice-presidents, but meets only rarely. A subset of this committee consitutes a resource board, which is concerned with policy allocations and problems of acquisition of small computers. There are, in addition, two user groups -- academic and administrative.

Policy in the review of requests for small computers constitute another problem in interaction with users. If the Center is not to be driven to the wall, such machines must be kept at a minimum. On the other hand, many already exist and some current requests cannot be rejected. If the mechanism for approving these requests involves approval by the Computer Center management, it is difficult to reject them without seeming unfair.

At the University of Texas at Austin, review is assigned to the Faculty Computer Committee. Their procedure is to approve such requests if they are for machines under $5000; over $5,000 the request must undergo a fullscale review. They attempt to encourage the use of such machines as data collection and remote input stations, with communication to the central computer. This review is mandatory, even if the source of the funds is Federal money.

Special Topic 2: CENTRALIZATION VS DECENTRALIZATION

Chairman: JULIAN FELDMAN
Assistant Chancellor for Computing
University of California, Irvine

JAMES FARMER
Director of Analytical Studies
California State Colleges

WILLIAM B. KEHL
Director of Computing
University of California
Los Angeles

EINAR STEFFERUD
Computer Management Consultant
Santa Monica, California

In the first presentation, Einar Stefferud outlined his view of the difference between centralization and decentralization and how an institution could choose between them. Decentralization may be considered to be a management tool for allocating resources to specific missions; centralization, on the other hand, is a management tool for economizing by means of sharing resources in support of two or more missions. They are thus different tools for different goals.

The price of centralization, Stefferud believes, is paid in terms of the managerial attention that must be paid to the organizational and political problems that arise in the use of shared resources. Without this attention, centralization will not work. The price of decentralization is the financial cost of multiple systems. If the potential savings from having a single system are large enough and truly attainable, then centralization makes sense.

The tradeoff is thus between managerial talent and computing resources. Both can be purchased, but their relative prices vary in different places and at different times. The administrative style of the institution also may dictate whether it buys computing or managerial talent. The Florida system, as described by Mr. Mautz, is one in which managerial resources are being used to achieve economies in computing. At other institutions, this may not be possible or even desirable.

Stefferud considers that a major top management issue is where the value judgments about computing are being made and where they should be made. Decision making about computing should be normalized and treated as a part of the normal budget and management system of the institution. Computing must be considered along and in competition with all other resources. The normal budget and management system is bound to be more trustworthy than special devices, such as giving the computer center director responsibility to set policy and allocate resources.

Another way to view this question is to ask, who is in control of whose resources and who should be in control. According to good management principles, accountability demands that administrators control the resources they require to fulfill their missions. If someone else has control over the needed resources, then that person is responsible for both the successes and the failures. When the computer center is given control over the resources that other agencies need to get their jobs done, the computer center director becomes a scapegoat for the failures of others, whether he deserves the blame or not.

When a conflict arises in such a situation, it is usually impossible to assign real responsibility. A researcher says that he did not get his job done because of the computer center, while the computer center blames the researcher for failing to understand the Center's sophisticated technology. There is no really good way to decide who is right. On the administrative side, a Dean may want to consider doing an administrative task by means of some other system than the central facility, perhaps using a shared system on a national network. But if he does not control his own resources, he cannot adjust or evaluate his policies.

On the other hand, Stefferud believes that too much freedom on the part of users to take their money and go elsewhere can totally defeat any possibility for a centralized computing agency on campus. Some coercion must be applied through the normal management and budget system. But the users should learn enough about computing to make their own value judgments and not depend on a computer center director to make decisions for them.

People as a Technical Resource

William Kehl agreed with Stefferud that computing must be viewed as part of the university's normal program and must be looked at and evaluated like any other part of the educational program. In institutions with highly centralized management, with decision-making power residing largely in the president's office, decisions about computing also will be made centrally. At institutions where the power is decentralized and the faculty makes decisions and controls the resources, decisions about computing will be made decentrally and a very different kind of computer center will result.

Why is it necessary to have a computer center at all? It is possible today to buy all the computing needed off campus. The value of the computer center is to be found in the people staffing the center, in their interaction with the academic user community, and not in the size of the computer or the price of the computing service. The important investment in a centralized facility is in the people who convert the power of the machine into useable service.

Service from a computer center is not simply raw computing power. Service in a much broader sense must be the goal of the center; it must include the technological competence to develop a proper environment for the users to be able to solve their problems. Economy drives and the retreat of many top people from computer center staffs back to academic departments, have severly restricted this competence and this kind of educationally oriented service at some campuses.

Too much concern has been expressed about economy, narrowly considering computing as a cost reimbursable activity and too little consideration has been given to education and educational goals. The most important requirement for the computer center -- as for any resource of the university -- is not that it be run with maximum efficiency but that it be productive and of useful service in terms of the objectives of the institution.

The California State Colleges

James Farmer presented some of the lessons learned at the California State Colleges in their attempting to centralize computing resources and policy. The California State Colleges (there are 19 colleges in the California State Colleges system) differ from many other institutions because some 75% of their computing work is instructional. The budget for instructional computing is $3.8 million per year. A network is now being constructed which, when it is complete in the summer of 1971, will allow a user to run his job at any center in the network from his own campus terminal.

The system is a distributed computer network in concept. All campuses are tied into the network, but with their own hardware. They range from Dominguez Hills, which has a 360/20 terminal, a programmer for consulting assistance, and a part-time computer center director, to San Diego, with a 360/40 and a complete staff. Each campus is expected to do 90% of its work on its own hardware and the remaining 10% over the network. This 10% is the part that is high cost, difficult, yet attractive and important to the faculty and students.

In order to get the quality and variety of software and software support needed, Farmer said it was economical to go to decentralized and specialized centers. The center at UCLA, is not the most economical local source of computing power, but it is used because of its range of software. It provides the kinds of services that academic people want. Further, it is possible to buy people time from UCLA: consulting time from people who are responsible and can solve problems. The Colleges can buy software maintenance services from UCLA as part of their computer service which would cost $200,000 per year from other sources.

The decision was made not to centralize all of the hardware because it was felt that better and more economical service could be provided by allowing each campus to do much of its own work, especially small jobs. Consulting personnel have to be somewhat decentralized to be readily available to the person with a problem. Policy making, planning, and system software were centralized. By centralizing planning, it was possible to coordinate decisions and to achieve cost savings. Because there are 12 identical hardware configurations, common applications can be written and system software development and maintenance centralized. The actual location of computing power is then a function simply of reliability and economics.

Reliability is a primary consideration to users; they must have consistent service, so that a job run today will be the same as an identical job run yesterday. In designing the State College system, Farmer said that communications presented the most difficult reliability problem. The telephone company did not seem able to solve problems in data transmission and took six months to shake down a system.

A network with many identical hardware configurations gains reliability through redundance. When Fresno State College lost its computer in a bombing, student jobs were run at Sacramento State College just two hours later. Student registration was delayed for eight hours, but only because of conflicting work at Sacramento.

The experience of the State Colleges presents two lessons in economics. First, check the software quality before buying. Software unreliability can account for 20% of the machine time; this will pay for quite a lot of hardware. A good machine with bad software is not a bargain. Second, economic projections must be based on not how busy people are, but on achievement: the time the equipment is operating, the cost of software support; and the time consumed by reruns.

The academic environment poses a large requirement for variety. Any computer center director who sets out to satisfy all of the requirements on his campus is a brave man. It is more effective to pool interests and divide responsibility among centers. The 10% of the computing at the Colleges done off-campus provides a great variety of software and services.

Suppose one of the nodes in the network wants a particular system that it does not have available itself -- say, Simscript. Simscript is offered by UCLA. If the quality of service on Simscript was not satisfactory to the user, it could apply pressure on UCLA to improve it. The UCLA Center views the Colleges as a customer, and will strive to keep it satisfied.

Decentralization and Special Purpose Systems

One point of view expressed was that for certain kinds of computing, smaller computers are better and more economical than a large general-purpose system: for example, providing large quantities of interactive computing in Basic for introductory courses. It may be better to supply students with access to small systems than to subject them to the load and line problems of large machines. A large machine such as Sigma-7 or PDP-10 may cost as much as $10,000 per port, excluding disk-pack storage. If its purpose is solely to interact with students in Basic, it is not as economical as a Hewlett-Packard system, which can run 32 terminals at a cost of only about $4000 per port. The Stanford Business School, rather than enlarge its 360/65 to accommodate a growing workload, got a small machine to run Basic exclusively. A highly specialized, dedicated system that provides precisely the service you want can be very cost-effective.

However, one must be sure that this very specialized service is really what is wanted. Small systems do not, for instance, provide file space to save student jobs. An institution with a specialized system runs the risk that users will want to start expanding it and turn it into a big machine in order to do things for which it was not intended. They start adding memory and building up big libraries of Basic programs, which may be going up a dead-end. If the intent of the users is broader than just filling a special purpose, it is better to go the general-purpose route from the beginning.

Technological advances in the small machine field do provide many new opportunities. The traditional economy-of-scale argument against the small machine is oversimplified and has been overused. If volume memory and high-speed I/O are not required,and if there is a steady and homogeneous workload, then a small machine can do a great deal of computing at surprisingly low cost.

Technology is moving in two directions at once. The users can choose either large, centralized machines for large problems, or and small, specialized machines for small problems. The ultimate system may be one of very large computers and intelligent terminals, where the user has his choice of running his job on his own terminal or passing it on to a large computer. There may be no separate small computer at all.

Further possibilities exist. UCI has a small grant from NSF to look into the idea of a network of small machines; Bell Telephone Laboratories has a system of loop communications rings to provide service to the 50 or so small computers in their system; Collins Radio is about to announce a message multiplexing system.

These developments place the computer center director, with his large and expensive machine, in a difficult situation. How does he sell his services to customers who may feel that there are other, more cost-effective alternatives? One way is to offer more sophisticated services than the small machines can offer. At UCLA, the Business School jealously guarded their own 1130, until the computer center improved its RJE capability to such a point that the business school decided they could get better service from the Center than from the 1130. The Center was also able to offer additions to APL which small machines could not match: graphics capability, file storage, and so on.

In general, it was felt that the computer center must stop acting like a subsidized resource and start being con-concerned about the needs, interests, and desires of its customers. It has to concentrate on better service; its attention must be directed to the user, not the political hierarchy. If the concern of the computer center is quality of service, and not simply economy, it is possible to survive. With their people resource, they can create the kind of service that customers need and can compete with the small machine and with other services that may be cheaper. This is not a lack of concern for economy; it is an awareness of the higher priority of other values.

Freedom of Choice

The policy of campuses with a central computing facility is generally to use this center unless there is a justifiable exception. The aim is to centralize planning, policy, and management. How are requests for special-purpose dedicated systems dealt with? The answer depends on the services required and how they can most efficiently be provided. But if the needs are expressed in terms of specific equipment rather than required resources ,as is often the case, the evaluation is hard to make.

It is awkward for the computer center director to approve such requests because he is not unbiased. Committees are scarcely better, since a user trying to prove a case against the computer center does not have the data or the resources that the computer center has. It is fairer to make the supplier prove his adequacy to do the customer's job. The principle that the half-life of a computer center director is inversely proportional to the degree to which he retains control over other people's resources has been called Stefferud's Law.

At institutions new to computing, the director may act as a pusher of free services, in order to introduce computing into the life of the institution. But the director must remember that this can be only a temporary situation. Eventually he must make the difficult transition from pusher to salesman, and the user must have the responsibility to state his requirements and back them up with dollars from his budget.

A good computer center director with a good system and good people can compete effectively with outside commercial alternatives; but many institutions cannot. If users have the freedom to take their work elsewhere, they will. The institution then has to pay for the work twice -- for the off-campus service and for the unused on-campus computer; there is no opportunity in the deficit-ridden center to improve the level of service and the system breaks down. Thus, there is a need for some kind of controls; absolute freedom will not work except for a top-notch center.

Costing and Control

One method of allocating computing resources and controlling the use of the resource is to divide up the available time and assign it to various departments, which then sub-allocate according to their own requirements and values. The allocation may be in the form of unrestricted dollars, or restricted dollars that can only be spent on computing at the center (sometimes known as "funny" money in contrast to real money which can be spent in any market). If the departments are given part real money and part "funny" money, the desire to earn some real money could encourage the computer center staff to provide better services, while the "funny" money will protect the center from being abandoned. The amount of real money attracted by the center would be an indication of its success in satisfying customer needs.

When computer time is allocated in this way, the computer center is able to avoid arbitrating between the conflicting interests of its users. Conflicts and complaints can be settled among peers or by some higher authority responsible for the allocation. At one institution, there was a rash of complaints about congestion and a slowdown in turnaround time. Analysis revealed that 10 individuals were using 50% of the academic computing allocation. When the figures were published, peer pressure solved the problem and the complaining disappeared.

One important decision is how much computing to allocate to student use. Some institutions have attempted to base a formula approach on the library analogy. Libraries have the advantage of a long history and established standards. There are no such standards in computing. Libraries are also well-understood and their importance is apparent to decision-makers and legislators; this, too, is not the case with computing.

Conclusion

The discussion left many questions unanswered. The University of California faces the problem of paying for $10 million worth of computing with $9 million in revenues. There are political problems that obstruct centralization beyond the campus level in many places. Computer center directors are being asked to establish policies for producing and marketing services whose value the upper levels of management do not yet fully understand.

In general, however, some important and useful conclusions were reached. Computing is a resource like many others and decisions about it must be made in accordance with the decision-making style of the institution. Some central services can be more useful to an institution than commercial service or decentralized dedicated systems. Finally, the computer center must appreciate that it has a marketing role and a responsibility to satisfy its customers.

Special Topic 3: MANAGEMENT CONTROL

Chairman: HARRY B. ROWELL, JR. *
Associate Director
Computation Center
Carnegie-Mellon University

RONALD M. RUTLEDGE *
Director - Computation Center
Asst. Professor - Computer Science
Carnegie-Mellon University

EDWARD SCHATZ
Vice President for Academic Affairs
Carnegie-Mellon University

Two general issues were covered in this session:

> First, a discussion of the concepts of management of computing facilities which are being employed at C-MU; and second,
>
> a case study presentation of the "before" and "after" implementation at C-MU of the management concepts.

Patterns of Management

In a rapidly developing new technology, very often emphasis is placed on advances in the technology, with little or no emphasis placed on the managing of the technology. The ultimate result is, and has been in the computing industry, management which is far behind in simply understanding the technology and even further confused in attempting to properly manage the results of advances in the technology.

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* Dr. Rowell and Dr. Rutledge have very generously contributed this summary of the presentation made during this discussion session. Because of a poor quality recording, a complete summary of discussion could not be made.

In a general statement such as the above, it is apparent that there are exceptions. However, a quick trace of the past fifteen years will indicate a predominance of poor management techniques and concepts. Consider the typical computing facility, how it started, how it grew, and where it is today.

First, a small computer was installed in the late 50's or early 60's. The justification for the computer was either to serve a very narrow need which was well-defined or to serve a broad and poorly-defined need. In either case, general use of the computer was promoted for various reasons. In a very short period the small machine was heavily loaded with poorly written, inefficient programs. Armed with statistics on loading factors, a larger, faster machine was "justified" and installed. The same loading pattern repeated itself and an even larger and faster machine was procured, etc.

During the growth described, a number of factors were working to promote the pattern. First, the technology advances were so rapid that proper usage habits could not be established. Second, in a new, attractive, rapidly growing field composed of a large number of poorly informed and trained people, the natural tendency to "empire build" was a guiding force. Third, the setting of what could be accomplished with the computer was not tempered with a complete understanding of the importance of properly preparing the people who would run the facility, and who would use the facility. Thus, large sums of money were committed by various funding agencies and by the organizations that installed computers. With the availability of "big money" poor management control was more easily accepted and in fact was condoned and promoted. It can also be said that poor management control of computing costs was caused by the lack of know-how of upper level management. Had upper management been more knowledgeable, the problems caused by poor computing management would not have been attacked by simply adding more dollars instead of critically analyzing what was being accomplished with existing dollars.

The forcing function which seems to have awakened upper level management has been the economic down-turn experienced in the last two years. Accompanying the recession has been a significant reduction in federal funding of university centers. As a result of tighter money policies throughout the organization, the computing complex and its management have begun to have to answer questions such as:

1. With the computer representing the ultimate in automation, why is it that the number of personnel continue to climb?
2. With the computer being so intricate, complicated, and vital to the organization's function, why is it that we trust its functioning to a number of low skill personnel?
3. With the very large charges for hardware and software, why do we allow vendors to supply us with a product that we must add even more people to our own payroll in order to make that product function as was promised or in order to change that product to function as we originally intended?
4. Is leasing rather than purchasing based on an intent to continue to change systems at such close intervals? Is it not historically obvious that with such large costs in bringing a new system to a smooth production level that we should plan to keep the system for a sufficient number of years to make it a sound investment? Should it be considered differently than the purchase of equipment for the factory or the building of a warehouse?
5. What can we do in the short run to cut our costs and retain present computing capabilities, and how can we prepare to control and predict our costs in the long run as our requirements for computing expand?
6. Where can we get the answers to these questions?

Fourth Generation Management

Recognizing the power of an economic recession as the main force behind the development of what Rutledge and Rowell now call Fourth Generation Management is a key step toward accepting the principles of the management techniques involved. Prior to the severe impact of the recession, computing facility personnel and users of computers placed immense importance on having the largest, fastest, latest, most expensive model of computer. Also, the greater the number of personnel employed in the computing complex, the more impressed were the users, and very often the more boastful were the computing facility management. Further, upper level management seemed to condone, if not promote, such attitudes by their leniency with poorly run, costly facilities.

Today, the management philosophies must be composed of two major objectives -- to obtain the services which are required and to cut and hold costs at their minimum. To accomplish these two objectives, the following techniques are important:

1. Select competent management - Competence of management is measured not only by technical qualification, but also by whether the individual understands, accepts, and can accomplish the objectives of cutting and holding costs at a minimum, while supplying required services. There is no guide to the selection of good management which will supplement the shortcomings of upper level administrators who do not possess the basic knowledge to properly evaluate their computing management. In this case, outside opinions and assistance should be solicited, but with the understanding that if a proper evaluation of existing management cannot be made by an upper level administrator, then a proper selection of outside assistance is equally difficult.

2. Make long-range decisions - Very few computing facilities are established to accomplish a short run objective. Most instances of installing and developing a computing system to a normal, smoothly functioning production level involve years of effort. Historically, time spans of most efforts exceed five years with a system being replaced at about the time that it is becoming a stable operation. There are very few cases where this updating of machines and systems have been truly justified and thus a significant increase in cost is caused not only by leasing instead of buying, but also by the continual rework of applications and software systems.
3. Utilize a Control Center - By proper physical arrangement of a computing complex to reduce the number of stations requiring attendance, the number of personnel can be lowered. Also, by selecting machines and operating systems which satisfy basic requirements as well as perform self-controlling functions, operating costs can be controlled.
4. Reduce personnel by increasing quality - the preferred posture to assume in a highly technical environment is one of employing personnel who are highly qualified. Instead of segmenting requirements by utilizing a larger number of partially skilled employees, consolidating requirements by employing a smaller number of highly qualified persons ultimately results in more and higher quality performance.
5. Evaluate all functions required to determine whether in-house, vendor or third-party service should be used. The final decision should be based on cost, quality, reliability, and the responsiveness needed.
6. Properly account for the use of all resources and commodities offered by the computing complex. Billing

mechanisms must be devised which enable the enforcement of policy as well as the charging for each commodity in a fashion that critical resources such as CPU cycles, storage, etc. can be allocated according to need and ability to pay. The computing complex should operate entirely on an "earn-its-own-keep" concept.

Fourth Generation Management at Carnegie-Mellon University

In less than one year, operating costs of the Computation Center at Carnegie-Mellon University were cut by over $1,000,000 employing the concepts previously outlined. Many of the concepts appear to be nothing new except when put into actual practice and then, with actual improvements in services, increases in the number of services offered, and improvement in machine performance, results become apparent.

The present management of the Computation Center assumed responsibilities in the spring of 1970. Since that time, while retaining all existing computers, the total personnel was cut from over 80 to under 30, service to C-MU was significantly improved and increased, and total cost per year was cut by over $1,000,000.

Among the changes made were:

1. Rearrangement of the facility to eliminate multiple stations which required staffing was step one toward fully utilizing the Control Center Concept.
2. Closed circuit television and multiple station intercoms with monitors located in the Control Center were installed so that all stations are under the control of one person (monitors in the center of the Control Center.)
3. The consoles of the IBM 360/67 and the Univac 1108 were located as the left and right sides of the Control Center so that both machines are monitored and under the control of one person.

4. Hardware and software for connecting the IBM 360/67 and the Univac 1108 were developed to create the essence of one computer. (At present, all transactions are one way from the 360/67 to the 1108. Within a short time the two-way function will be completed.)
5. Hardware on the Univac 1108 such as Fastrands was eliminated, and hardware was added or repaired on the IBM 360 such as faster extended core, a faster disk system, and more channels. The changes were designed to enhance the capabilities of the 360 and to prepare for the combining of the 360 and the 1108. With completion of the two-way network, the 360 will be the pathway both via remote terminals, remote readers, and local readers to the 1108 with file space on the 360 also available to the 1108. The major functional designation for the 1108, as a result of the configuration selected, is to supply "number crunching" services while the 360 is to supply conversational computing.
6. A major portion of the hardware was converted from lease to purchase. The units not purchased were those chosen to be eliminated or replaced. For instance, the communications equipment on the 360 will be replaced in the near future with PDP 11's.
7. Where possible, equipment was purchased from the vendor offering the best equipment and/or the best price and terms. For instance, 4 million bytes of extended core memory was purchased from Ampex Corporation and a 3 controller, 25 disk drive system manufactured by Century Data Systems was selected.
8. In-house maintenance of hardware was initiated. Full maintenance of the Univac 1108 was assumed in August, 1971 and partial maintenance of the IBM 360 is presently being performed with full responsibility scheduled to be accepted by September, 1971. Not

only has the cost of maintenance been lowered, but also reliability has improved significantly.

9. The operations staff was completely eliminated, with the major steps in the establishment of the Control Center completed, the normal requirements for from eight to ten operators per shift was changed to a requirement for one fully-trained, fully-qualified systems programmer and one assistant.
10. Funding of the Computation Center was changed to prepare for a complete "earn-as-you-go" operation. All use of the facility is funded either by normal budgeting to departments or via funded contracts and grants. Therefore, the Computation Center must earn complete support by selling its various services.
11. As a sub effort within number 10, a completely new resource billing scheme was devised which enables the control of more critical resources and allows the enforcement of policy by varying the prices of commodities depending upon demand requirements. The accounting and pricing scheme has proven to be very instrumental in distributing properly the commodities available.
12. User self service was initiated to make possible reductions in staff required to handle job input and output. User operated card readers and printers were installed in the public areas of the Computation Center. The WATFIV system was installed to carry the bulk of the smaller student jobs with users inputting their own card decks. With WATFIV jobs given short turn parameters, the user goes directly from the card reader to the user printer and detaches his output. Regular system users also input their own card decks. At present, output is placed into bins, but within a short time an output call system will be completed which will allow output to go to a dataset. The user will call his output from a terminal located at the user printer and will tear his own output when it is complete.

Conclusion

While the prior descriptions give a number of broad areas of change, an even larger number of individual policies and procedures have been altered in the past year. The ultimate objective, to fully exploit the concepts of Fourth Generation Management, was always the principal factor behind each change. Today we are approaching the point where the basic concepts are installed and functioning to reduce costs and increase services. Over the next year we will further refine and develop the techniques and expect to further cut operating costs in the future.

The operating plan presently being used calls for amortizing existing equipment over a six year period. This will mean that the shortest use time for any one system will be at least nine years since the last machine was installed three years prior to purchase. With improvements planned for both hardware and software, any increases in demand will be met without making costly computer system changes. Also, we estimate that by 1977 standard interfaces will be available and assembling your own system will be commonplace. If system updates are required at the end of the write-off period, we expect to accomplish such changes with partial system add-on instead of complete replacement.

Special Topic 4: GOING COMMERCIAL

Chairman: JOHN HRONES
Provost of Science and Technology
Case Western Reserve University

MICHAEL O'HAGAN
Director of Computing Laboratory
Southern Methodist University

The basis of the discussion was the experience of the Chi and Alpha Corporations, two commercial enterprises set up by universities to supply computing services to academic and commercial customers. A presentation had been made earlier describing the Chi Corporation*. Michael O'Hagan presented a description of Alpha, the corporation set up by Southern Methodist University.

The Alpha Concept

Unlike Chi, Alpha is not owned by the University it serves. It is owned by two University-related foundations, the Gulf Insurance Company, private individuals, and Alpha consultants and employees. By means of a rather complicated set of financing arrangements, an initial $150,000 grant provided the base for the company which now holds a $4 million computing system.

The relations between Alpha and SMU are complex. Although the Alpha Corporation and its computing facilities are located on SMU property, it is a commercial entity and pays taxes on that property. The computer system is operated by

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* see above, p.xxx for Mr. Hrones' presentation.

SMU personnel under contract to Alpha. SMU leases one-third of the available computer time from Alpha under a long-term arrangement.

Further financial assistance is obtained through periodic sale of convertible debentures by Alpha to the Gulf Insurance Company, which is a subsidiary of the University Computing Corporation (UCC). UCC itself is the second major customer for Alpha's computing services. As part of the long-term arrangements with UCC, Alpha maintains software compatibility with UCC's own computer system. Thus UCC can use the Alpha facility to run its own internal systems and overload.

Alpha's computer system consists basically of a UNIVAC 1108 and a DEC PDP-10, utilizing a COPE Controller front end. This configuration gives the system the ability to communicate with high-speed remote batch terminals ranging from 2400 to 9600 BPS and relieves the 1108 of any necessity to communicate directly with the outside world. Alpha is currently considering the acquisition of an IBM 370 and possibly a CDC 6400, which would allow them to interact with virtually any major computer user.

The overall aim of Alpha goes beyond providing computing services to SMU and commercial customers. The Alpha Consulting Group is a group of consultants made up almost exclusively of SMU faculty members to provide software development and consulting services. Alpha provides marketing and administrative services to the consultants, as well as computer time. The consultants are offered an equity position in Alpha by means of a stock-option plan.

Alpha is involved in a number of other activities. It offers its services to other colleges and universities in the area and looks forward to becoming a regional educational computing center. It is designing a vocational course of study in computer programming and technology in cooperation with Elkins Institue; and it is acting as sales representative for various terminal manufacturers.

Since Alpha has excess computer time available, it is offering computing to some small companies in exchange for stock in these companies. Because it cannot offer support personnel, it selects companies that have considerable internal competence and can make use of the computing without much assistance.

The Alpha staff consists of about six to eight full-time professionals plus the consultant group. The SMU operating staff of the computer center amounts to about forty persons.

Security

In order to get insurance for the facility on the SMU campus, a number of security precautions had to be taken. These include: ionization detectors; an air-conditioning system that will shut down automatically if someone puts acid into the air intake; transparent partitions made of jewelry glass at $8 per square foot; for all major windows and doors ultrasonic motion detectors; solid walls without windows; and an elaborate closed-circuit remotely controlled TV system. Further, campus security officers are located in the building and they are able to monitor the operation on a twenty-four hour basis.

O'Hagan said there was a desire to make the center as accessible as possible for student use, but students have access only to the peripherals. There is no way they can get to the main camputers. The machine room is totally sealed.

These precautions were taken to satisfy the insurance company. But O'Hagan believes they are a good idea for a commercial as well as an educational center. He does not consider the precautions difficult to live with, nor unduly expensive for the protection of a multi-million dollar investment. They cost about $5000. The insurance premium is about $9000 per year.

Chi Corporation is not located on campus, but is nearby. There is frequent concern by business men and prospective customers about security and protection from students.

Alpha has not found security to be a matter of concern to their customers. They are aware of some possible friction between students and commercial customers, however, and attempt to isolate them in different user areas, each with its own teletype complex and remote batch terminal. The commercial customers enjoy the attractive young ladies, but seem to resent having the hairy boys with sandals around.

System Architecture

The Alpha computers were a compromise between the newer, more imaginative possibilities being developed but not yet working at the time of decision and a more conservative complex of equipment that the staff knew would work. It was clear that the 1108/PDP-10 combination could be operated efficiently.

Much depends on the software. As hardware efficiency improves, the cost of software and its relative importance goes up. Systems programs have gotten much more complex, yet systems programmers have not gotten more efficient. The Alpha system was written by some graduate students, using the UCC Fastback software that was already in existence as a base. This seemes to Hrones, in retrospect, a weak approach. The software will be redone this summer in order to speed up the operation.

Alpha and Chi

Alpha was based, to some extent, on knowledge gained in the Chi experience. The group that designed Alpha, however, disagreed with the Case Western philosophy of retaining total equity in the company. It felt the need for more computing power than the University itself could afford and were able to use the grant it received to get it. It wanted to spread the equity around. Presenting the possibility for gaining equity to the faculty it felt would help to attract and keep the high-quality faculty the University needed. Thus, the consulting group was designed in from the very beginning, as an integral part of the plan.

Chi gave consideration to the possibility of disposing of equity, but finally decided against it. It found it enormously difficult to operate without capital and was forced to postpone doing things they would liked to have done. Now that the business is launched and moving toward profitable operation, however, the University can begin to pay off its deficit. When this is done, Hrones believes Chi will become a very profitable and attractive business and the university will be able to sell ownership at a much higher price than would have been possible at the beginning. A planned expansion to a larger hardware system will impose greater capital requirements. It is the intention of the Chi management to build up a reserve over a period of years to facilitate this move without totally borrowed capital.

At both SMU and Case-Western, the administrative as well as the academic computing is done by the respective companies. Alpha combined the two from the start. Chi initially did only the academic work, but gradually is taking on the administrative work as the administrative hardware on the campus is being phased out.

The management of these enterprises calls for a mix of people experienced in marketing and business operation and those with a knowledge of computing in the university environment. At Chi, there was not time to train academic people in business management; nor, for that matter, would the board of directors approve such a move. It insisted on bringing people with experience and knowledge of operating a profit-making company. But when the University is a major customer, it is important that the company be sensitive to the University world. A delicate balance must be maintained.

Alpha decided to retain management and operation within the University, partly because the staff wanted to stay with the University, and partly because the University wanted to retain control of the operation. It is their intention, for example, to limit the number of commercial users so that the University remains the largest and principal customer.

In setting up the Chi Corporation, a very careful study was made of the commerical and industrial environment in which it would operate. The market forecast made at that time has proved to be reasonably accurate with the exception that time and effort required to develop a large user were underestimated.

Both organizations realize the critical importance of competent staff and the need for a substantial initial financial backing by key individuals and institutions. The opportunities for advancement and reward of Chi staff are greater than normally exist in university computing centers. The Corporation is also considering the implementation of a stock plan to attract and hold top-level employees and an employee profit-sharing arrangement.

The time required to plan and set up the Chi Corporation, from the beginning discussions to operation, was about two years. Alpha required about one year, but partly because a great deal was learned from the Chi experience.

Special Topic 5: THE COMPUTER, AN AUXILIARY ENTERPRISE

Chairman: E. R. KRUEGER *
Director, Computing Center
University of Colorado

The University of Colorado Computing Center is responsible for all academic (research and instruction) computing done at the University. Some administrative work is done by the Center -- the remainder on a separate facility. The Center is organized as an auxiliary enterprise. In this setting it is charged and charges for all services received or rendered. Organizationally, the Center reports to the Office of the Provost. It is internally structured as shown in Figure 1. Not shown in this Figure are:

1. An advisory committee representing all schools, colleges and special institutes which make significant use of the facility.
2. A terminal users group (there are nine remote batch terminals interfaced to the system).
3. Several faculty applications program library groups.

The Center utilizes a dual CDC 6400 system which provides both batch and interactive service to its user community. Of special note is a significant graphics research activity in problem-oriented applications packages. Through this and other applications-oriented research projects, the Center is able to continually broaden its user community base. This in turn results in new applications and increased demand for the totality of services the Center provides. One facet of the definition of the auxiliary enterprise concept at the University is that the Center can contract with outside agencies to provide service. Althought the Center does not solicit commercial users, Federal and State agencies make significant use of the University's computing capability. In particular, the Colorado State Department of Highways utilizes this capability to process all engineering work for that Department. This type of interaction, in addition to providing monetary support to the Center, enables an exchange of technical knowledge beneficial both to the Department of Highways and the University of Colorado. This is, in a real sense, a practical implementation of the classic role of the state university and a media of providing services to the state community at large.

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* Dr. Krueger has very generously contributed this summary of his presentation made during this discussion session. Because of a poor quality recording, a complete summary of discussion could not be made.

The batch job load at the Computing Center has grown roughly at a 40% rate annually. The total batch job load history since the Center was organized in FY62 is shown in Figure 2.

The charging structure for services provides for three categories of users: University, Other Universities/Government Agencies, and Commercial. University usage includes general fund and grant and contract usage. The income breakdown percentage wise by category for FY 1971 is given in Figure 3.

Expenditures budgets for the Center include, in addition to the usual costs, rent for space, administrative service charge and interest on monies lent to the Center by the University for hardware purchase. The expenditure budget for the University for instructional capability was $14.36 per student FTE in FY 1971. This is well below other universities of similar size and stature.

Summary

Establishment of the University of Colorado Computing Center as an auxiliary enterprise in which all costs are exposed and budget deficits/surpluses are absorbed by the Center has resulted in:

1. Total computing capability which the University could not afford to finance with its resources alone.
2. Lower unit cost to the University.
3. Active development of computer applications by the Computing Center.

Special Topic 6: REGIONAL SHARING

Chairman: THOMAS GALLIE
Director
Computer Science Program
Duke University

BERTRAM HERZOG
Director
Merit Computer Network
Michigan

ARTHUR MELMED
Office of Computing Activities
National Science Foundation

LELAND WILLIAMS
President
Triangle Universities Computation Center
North Carolina

The discussion centered about two specific regional networks, TUCC and MERIT. An opening statement by Arthur Melmed presented some perspectives on the general issues and applications of regional centers.

Regional sharing of administrative systems, Melmed stated, has been slow in coming because of the problems of data confidentiality and lack of standardization among institutions. There seems to be little impetus for cooperation in this field. Except for the current work at WICHE, sponsored by USOE, there is little effort and no government sponsorship of cooperative efforts. Libraries, too, seem to be slow in developing regional sharing methods, despite an evident need. The reasons are probably to be found in a combination of technical and political factors.

Regional activities are much more prominent in research. By a pooling of financial resources, a regional computing center can offer a mechanism to acquire the most powerful computing capability for all of the member institutions. This has the advantages of being able to handle uniquely large problems that cannot be solved on a smaller system; and of allowing in theory for the simultaneous solution of a number of smaller (including student) problems economically.

NSF has funded about 20 regional centers for research and instructional use. It was not expected that all of these centers would continue to be viable after NSF support was withdrawn. Yet a fair fraction of them are going to be successful on their own. Of the first ten or so, 50% have been able to continue after the end of their grants. The most recent ones to be funded were established with the understanding that they would continue.

The first applications of the regional centers were research-oriented; as more instructional work goes on the machine, the requirements change. Research often means small I/O and large arithmetic requirements. Instructional use can make just the opposite demands. There is some question as to whether economies of scale apply to a center in which the overwhelming burden of work is instructional, involving many small programs in problem-oriented languages, increasing I/O requirements,and proportionately large communications costs generated by a large but distributed constituency. The mini-computer may become a significant competitor to the regional center for instructional applications of this kind.

Another kind of instructional use, however, does require larger machines and a regional center can be advantageous. Large programs, including simulations, for example, cannot be run on a small machine nor transferred to a college with a mini-computer, because of the limited memory size or speed of the smaller machines. They cannot even be transferred easily to institutions with large machines because of machine differences and the need for experts in residence to maintain the program. The advantage of a regional center is that it allows a program developed at one location to be used by all of the institutions in the region.

Another possible use of regional centers is to provide accessible dynamic archives for instructional software. The center can furnish a directory with information for teachers on what a package does, how it works, how much time it takes, and so on. There must be a facility where the teacher can browse through programs as he browses through a book before assigning it to his class. The regional center can supply these services, as well as running the programs the instructor decides to use.

In this way a market mechanism may begin to emerge. Some entrepreneur may take a program developed by one institution, document it, catalog it, and keep it available on-line for people to try. He takes a chance that people will want it. If he is right, he and the developer of the program will gain. If he is wrong, he will lose and the program can be dropped from the catalog and from the machine. Who will be the entrepreneur -- institutions of higher education; book publishers; commercial time-sharing services? It is not yet clear.

MERIT

The MERIT computer network is a cooperative effort of the three large state institutions in Michigan: Michigan State University, the University of Michigan, and Wayne

State University. Since 1966, they have been investigating the problems of inter-institutional cooperation, particularly in the use of computers and electronic media. A proposal made to NSF for a computer network was funded in 1969. This network will become operational in the summer of 1971.

For various reasons -- political as well as technical -- the plan confines itself to joining together the computer centers of the three institutions. These are the only three institutions in Michigan that already have major computing resources. The other 10 state institutions are part of the State Board of Education and are not autonomous (as are the three cooperating institutions). Later developments may allow MERIT to expand and offer services to some or all of these institutions.

MERIT is a communications system that will link the three centers together. A network of dissimilar machines presents obvious problems: incompatible word sizes, incompatible operating systems, and so on. However, it was decided that no attempt would be made to legislate to the individual institutions the kinds of machines they should have. It was felt that it was important to allow independent innovation to continue at the three institutions and not constrain them in any way.

The current hardware configurations are as follows. The University of Michigan has a duplex 360/67, which is operated under its own time-sharing system. There are 60 or 70 ports for remote access and a variety of terminals and RJE's are used. Wayne State University is in the midst of a change. They are going to a half-duplex 67, with plans to go to full duplex eventually. Michigan State has a CDC 6500, which is used for administrative as well as academic applications.

The special hardware for the network provides each of the three machines with an I/O processor as an interface with the telephone system (connected through the multiplex channel on the 360/67 and the peripheral processor on the 6500).

The system will make use initially of a telephone system that already exists and is the property of the universities. Eventually, when the requirements and use are better understood, this will probably be replaced by MERIT's own telephone system. The communications processors allow for considerable growth.

In the MERIT scheme, customers do not access the distant computer directly. They insert their job into their local computer, which then forwards it in accordance with the user's instructions. This precludes the development of the system to include other institutions that do not have computers, or the use of the network when the local computer is not available. But these problems will be dealt with later, after the system has become operational and when the extent and the nature of the traffic are better understood. All that the network presently guarantees is to allow the user to access any of the three machines as if he were accessing his own. MERIT simply delivers his messages to the appropriate computer. It thus presents a fairly open laboratory for exploring the problems of computer communications.

TUCC

The Triangle Universities Computation Center was established in 1964 as a non-profit corporation by the three major universities in North Carolina: Duke University, The University of North Carolina at Chapel Hill, and North Carolian State University at Raleigh. The primary motivation was economic: to give each of the institutions access to more computation at a cheaper rate than they could afford individually. TUCC received its initial grants from NSF and from the North Carolina Board of Science and Technology. It was established in Research Triangle Park, which is geographically as well as politically neutral territory with respect to all three of the campuses.

TUCC supports educational, research, and (to a limited extent) administrative requirements at these universities, and also at 42 smaller institutions in the State by means of multi-speed communications and computer terminal facilities. TUCC operates a 3-megabyte, telecommunications-oriented 360/75 using OS/360-MUT/HASP, and supporting a wide variety of terminals. For high-speed communications there is a 360/50 at Chapel Hill and 360/40's at North Carolina State and Duke. The three campus computer centers are truly and completely autonomous. They view TUCC as simply a pipeline through wich they get massive additional computing power to service their users.

The present budget of the center is about $1.5 million. The 360/75 is now running at about maximum efficiency; that is, there is nothing which could be added to it that would boost its capacity significantly (it now runs about 4200 jobs per day). Plans are being made for a move to a larger machine -- a 370/165 will double the capacity of the center at only about 10% increase in cost, preserving the economy of scale.

Several notable advantages (besides the financial ones) have accrued to the three universities using TUCC. First, they share a wide variety of applications programs. A program developed at one of the institutions can be used anywhere in the state with no difficulty. Second is a significant impact on the ability of the universities to attract faculty members who need large-scale computing for their research and teaching. Third is the ability to provide highly competent systems programmers (and management) for the center. In general, these personnel could not have been attracted by the individual institutions because of salary requirements and because of system sophistication considerations.

The North Carolina Board of Higher Education has established an organization known as the North Carolina Educational Computing Services (NCECS). This is the successor of the North Carolina Computer Orientation Project, which began in 1966 without NSF support but is now one of those referred to by Mr. Melmed as a recently funded NSF regional center which was expected to continue. NCECS participates in TUCC and provides computer services to other educational institutions in North Carolina: presently 42 public and private universities, junior colleges and technical institutions plus one high school system. NCECS serves as a statewide campus computer center for these users, providing technical assistance, information services, etc. In addition, grant support from NSF has made possible a number of curriculum development activities. NCECS publishes a catalog of available instructional materials; it provides curriculum development services; offers workshops to promote effective computer use; and visits campuses, stimulating faculty to introduce computing into courses in a variety of disciplines. Some of these programs have stimulated interest in computing by previously uninterested institutions and departments. One chemistry department, for example, ordered its first terminal in order to use an NCECS infra-red spectral information program in its courses.

The software for NCECS systems is developed from a number of sources. Some is developed by NCECS staff to meet a specific and known need; some is developed by individual institutions and contributed to the common pool; some is found elsewhere, and adapted to the system. NCECS is interested in sharing curriculum-oriented software as broadly as possible.

Serving smaller schools in this way is not only a proper service for TUCC to perform, but is to its own political advantage. The state-supported institutions, UNC and NCSU, can show the legislators how they are serving broad educational goals with their computing dollars.

SYSTEM ADVANTAGES

The point of the MERIT system is to provide each institution with more resources than it has now: both in terms of kinds of computer hardware and in terms of software. There will be less need to duplicate the same or similar programs in different machines. Programs in different machines can be linked together without the laborious transfer of information from one machine to another by off-line media. Ultimately, the outlying universities and colleges will have access to all the MERIT resources, by becoming a customer of any one of the nodes.

The ARPA concept significantly overlaps that of the regional network idea (particularly as structured in MERIT). Like MERIT,ARPA is a network of dissimilar computers, although much larger and existing over a much broader geographic area. MERIT, in its initial configuration, is a minimum network, but in the future, the possibility of joining it to ARPA should be considered. Eventually someone in the MERIT system will want to use a computer which is not part of that system. A number of special resources are not available to MERIT; including very large memory systems, and graphics software now concentrated on PDP-10 computers. Networks are of great interest to computer people, but users are interested only in the nodes. What new nodes should be developed? Given finite resources, how much should be spent on the development of new nodes and how much on distributing service to those nodes?

The view was expressed that the reliability of a regional center, because of its innate complexity, will never be better, and may sometimes by worse, than the reliability of the individual computer center. When a job requires two computers and a communication link, the probability of completing it without a failure is obviously less than if it requires only a single computer. Yet, there was general agreement that additional resources (duplication of facilities for the sake of backup) would not be worth what they would cost. Reliability is important but not important enough for users to be willing to reduce service in other areas to pay for it.

A regional system should provide an opportunity to develop a whole new community of users. The opportunity exists to form interinstitutional groups of users with related interests, and build systems specifically for their benefit. Currently, it is necessary for a MERIT user, if he wants to take full advantage of the available systems, to be able to deal with all three of the operating systems; this is rather a stiff requirement for many users. Systems are being contemplated, however, in which a user can sign on and immediately enter a special environment or "cocoon." There might be, for example, a cocoon for social scientists, which allow him to use systems of interest to him in any of the three computers in terms of a single, consistent language. This should have some impact on getting people in different institutions to talk to one another and to use computers creatively.

STABILITY, FINANCE, AND MANAGEMENT

John Alman of Boston University noted that MERIT and TUCC are basically different kinds of networks. In TUCC, a single node provides basically all the service (although software is being developed to change this somewhat); all other nodes are users of this central resource. In MERIT, all of the nodes are both contributors and users of service. The question he posed is this. Is the MERIT system basically stable or will it eventually approach the TUCC position? It may turn out that those nodes which supply a lot of computing to the others will become dominant and move into the supplier role; others will then become more passive and move into the user role. The centers that are getting more money than they are spending will be able to improve their services and improve their rates, thus attracting more business.

There is no a priori relationship among the participants of MERIT, Herzog explained. They are willing to start out, learn what the problems are, and deal with them as they emerge. But the stability problem to which Mr. Alman refers is closely related to a financial question. The cash flow among institutions is not likely always to be zero. What happens when the books are balanced out and one university is a creditor and another a debtor? Will the universities apply restrictions on where the computing dollars can be spent? Who will be in a position to control the flow of dollars?

There will be two periods. In the first, everyone will be encouraged to try out the system, do what they please with it, and learn how it functions. When the system becomes operational, however, there will be a need for procedures, policy, and a mechanism for the automatic exchange of money. There is a close analogy in the management of the individual campus computer center. When it was first established, it had a great deal of freedom; anyone could use this resource any way they wanted to. As time went on, there had to be an accounting and a more normalized system with budgets, allocations, and priorities. In the case of the network, the day of accounting may come sooner because of the larger sums involved and because the money will be going off-campus. The danger is that the day will come too soon, and the network will not be given enough of a trial to realize its natural development.

A key issue is the operational status of the MERIT director and staff. If money moves freely and without constraints, there is little need for management. On the other hand, if tighter control is required, the MERIT management may be required to assume a dictatorial role.

The situation at TUCC is basically different and is now relatively stable. Each of the campuses retains a good deal of autonomy, and decides individually the rates it will charge the customers on its campus for the computing it gets from TUCC. These rates are not the same at each campus.

MERIT has yet to face a number of problems. If it is cheaper to run a FORTRAN job at one campus than another, will all FORTRAN work travel there? How can rates be stabilized? The centers currently have very different rate structures, based on different financial policies, and established for internal reasons. Changes are going to have to take place and the rate structure may become highly negotiable and strategic. These will be difficult problems and the solutions are not yet in sight.

Special Topic 7: REGIONAL SYSTEMS FOR HIGH SCHOOLS AND SMALLER COLLEGES

Chairman: RICHARD LEHMAN
Director
Middle Atlantic Education and
Research Center

EUGENE FUCCI
Assistant Director
Kiewit Computation Center
Dartmouth College

Regional centers have most often been built with one or a few large research-oriented universities providing the financial and managerial stability to the organization; service can then be provided to smaller colleges and other institutions from this base. Some attempts have been made without the central university, groups of small colleges banding together and cooperatively organizing and operating a computer center. This has proven to be a more difficult system to construct.

At this session, presentations were made of two regional systems that fall more or less into this model. MERC began as such a system; however, financial difficulties made it necessary to change its structure, at least temporarily. The Dartmouth system began by serving a single institution and was later expanded to become a regional center.

The discussion that followed the presentations focused largely on the mini-computer. Its capabilities were compared with service from a regional center from the point of view of the small college.

MERC

The Middle Atlantic Education and Research Center (MERC) is a group of institutions without substantial computing power that decided to create a cooperative center, starting from scratch. MERC did not take over any of the hardware, administrative structure, or other computing resources of the member colleges, but started from a totally new base. MERC has suffered some of the problems of a totally new organization, but according to Lehman its members feel it has been a success and should continue to exist.

MERC operates as an independent corporation, governed by a board of trustees. This board consists of three representatives from each of the member institutions. At present, there are 11 such members:

- * 5 four-year liberal arts colleges, ranging in size from 500 to 1900 students;
- * 5 public high schools, also ranging widely in size;
- * 1 private preparatory school.

The responsibilities and options of the trustees (and of the member institutions) were never made fully clear, creating the greatest problem MERC has had to face. The board of trustees has complete authority to set the operational policy for the center, but its responsibility for the financial support and management of MERC is undefined.

The current operation provides a range of services; time-sharing for student use is the major product. Of the time-shared use, 60-70% is in Basic, although a number of other languages and systems are available and contemplated. Current batch use is made up principally of a small amount of high school administrative work, which is expected to grow enormously in the future. This service now includes minimum grade-card printing and course scheduling for about six high schools.

The center also does a very modest amount of commercial work. As a tax-exempt corporation, MERC does not solicit such work but accepts it when it is asked.

Prices are now being revised, so no precise figures can be quoted. Prices for time-shared service are a function of connect time, CPU time, and storage; the total works out to about $7 per terminal hour for most users. The smaller schools in the system use less than 40 hours per week. Franklin and Marshall, however, has five teletypes in almost constant use.

When the NSF financial support was terminated, the MERC trustees were not in a position to accept financial responsibility for the actual costs of operation on the part of the member institutions. MERC was planned during a period of more optimistic financial projections; the costs of the operation have been more difficult to recover than had been anticipated.

As a result, early in 1971 the member with the greatest investment in the center, Franklin and Marshall College, was given authority by the trustees to serve as financial and business agent for the center. Franklin and Marshall advanced money to remodel space on its campus to house the center and took advantage of a discount possibility to buy the computer from the manufacturer. Franklin and Marshall will take financial and managerial responsibility for the operation of the center until the members are able to share in covering the expenses.

In accepting this responsibility, Franklin and Marshall was forced to cut back on the costs of operation so as to be able to provide some services at costs acceptable to the users. It cut hours of operation temporarily, but soon restored them to the original 8 a.m. to midnight. It cut staff by 50 to 60% and the center is running, in effect, with only a skeleton staff. It cut back publication of the newsletter, dropped three programmers, replaced professional operators with students, and discontinued development activities. The director of MERC, formerly on the payroll of the center, is now employed by Franklin and Marshall, as is the business manager.

Most of the tangential support activities have been eliminated entirely: courses, training, symposia, and user consultation. However, MERC recently received a college science improvement grant from NSF for a faculty training program which has made it possible to reinstitute some of the latter activities.

In order to stay in business and become financially stable, other changes are taking place. Time-sharing service, for instance, although it will certainly continue to be a very important product, will not be the main dollar producer. More attention is being given to administrative data processing in the batch environment, and all of Franklin and Marshall's administrative work is being converted from an existing 360/20 system to run on MERC. Administrative packages will be made available to other colleges.

The Commonwealth of Pennsylvania has also been restructuring its computer services and MERC is in an excellent position to be given responsibility for the data processing work for 22 school districts in the area. This will include all administrative work for the districts, as well as most of the academic work (excluding only CAI).

Thus, MERC, originally conceived as a center run by and for a group of smaller institutions, was forced by financial problems to fall back on a major member. But there is a strong determination to continue in operation in order to provide services to smaller colleges and high schools in the area.

Dartmouth

Dartmouth was one of the earliest academically-oriented time-sharing systems and has served as a prototype for many of the regional centers that have been developed. Their regional activities were first supported by an NSF grant. This grant has now been terminated and the regional network, although it suffered some attrition, is still very much in business. Unlike MIT, another early and outstanding center, the objective of the Dartmouth system has been service to the non-scientist, the lay user.

The managers of the Dartmouth system consider themselves providers of service, as in any common utility; they avoid the question of what the users are doing with their services. When someone wants to know what is being done in some application area, the staff directs them to users in that field. The center has been instrumental in setting up department-to-department seminars and teaching sessions in which the users themselves demonstrate for novices in their own academic fields the way they have been using the time-sharing capability of the center. The center serves as a catalyst for applications and a consultant for systems programming.

A regional center can provide a number of very valuable services for its members, a major one being the capability to share software. Dartmouth offers more than just computer time on a GE 635. It considers its hardware worth $3 million, and its accumulated body of software worth some $10 million. Fucci considers this the real bargain in using the Dartmouth time-sharing system.

And the Minis

A major competitor of the regional network is the mini-computer. Like the Volkswagen, it seemed harmless enough when it first appeared; but now its low cost and general availability present a real threat to the regional networks.

The regional centers, such as Dartmouth, regard the mini salesman as promising the potential buyer something for nothing. "Why pay money to the regional center and have nothing to show for it," the salesmen ask, "when you could be spending that money in buying your own machine?" They do not tell the customer that the machine is too small to run many of his problems unless he also buys additional (expensive) devices. They do not tell him that the system is limited in subroutine and file support. They do not tell him that his system has nothing corresponding to the software and personnel support provided by the time-sharing system, support which is far more important than hardware for many users. They do not tell him that the languages, systems, and editing capabilities are very limited and there is no way in which the customer can expand them. They do not tell him that the larger the computer, the easier it is to use, because of the more specialized language capabilities that are possible.

Fucci admits that there is a place in education for the smaller computer; even at Dartmouth, there is a PDP-9 for the students to use when they are interested in exploring machine languages and systems. But for the broad range of users, he says it is no match for time-shared service.

Others argued, however, that Dartmouth and its principal customers are very special colleges. Dartmouth students consistently have SAT scores between 600 and 800; some schools rarely get anyone with a score over 600. Dartmouth had NSF support to get started. The average small liberal arts college has no science program of any distinction, cannot approach NSF, and has no way of getting a subsidy to get started. Dartmouth is a residential college, with students and faculty always on the campus; some urban colleges operate from 9 a.m. to 5 p.m.

These other kinds of colleges want the computer system that provides the minimum services that students need, at the cheapest possible cost. To them, using the sophisticated capabilities of the Dartmouth system to let kids run Basic programs is like using an elephant gun on a mouse. The mini-computer is a very reasonable alternative. A Hewlett-Packard 2116 system, for example, can provide time-shared Basic service to students for less than $2 per terminal hour. Dartmouth offers service in this price range (their prices range from $2.50 to $3.50 per terminal hour) but the figure is expanded when it is retailed through NERCOMP and when the communications and terminal costs are added. The additional facilities, languages, and support that Dartmouth can offer are certainly attractive; but some schools simply do not have the money to pay for it.

There was agreement that a mini does provide certain services, and there are services which can be provided by a time-sharing system that are not possible on a mini. The questions, however, were:

-if you cannot have both, which is more important?
-for which are the bulk of student users better off?

In many colleges, the bulk of the use is by students in Basic. Some believe this kind of service is most economically provided by a mini-computer. The students and faculty who can and will make use of the broader services of a more general time-sharing system is very small, and can be provided on a different basis. Simply because there are a few who can use the more sophisticated service does not justify providing it to everyone.

A few wondered if perhaps there is room on the smaller campus for both the mini-computer and the time-shared service. Some systems have been constructed based on the idea that the small computer should be available to do the small jobs and that big jobs should be sent to a major center. Ideally, a school might have access to both kinds of service.

Special Topic 8: SMALLER COLLEGES

Chairman: CHARLES MOSMANN
Consultant
Newport Beach, California

BRUCE ALCORN
Associate Project Director
Southern Regional Education Board

JOHN CAFFREY
President
Educational Systems Research Group

VINCENT SWOYER
Director, Computing Center
University of Rochester

The smaller college has a range of alternative forms of computing available to it, from the regional center and commercial services to the mini-computer. There is no one form of service which is uniquely best for all institutions; nor can the decision be made by some agency other than the college itself. It must make its own decisions on the basis of its goals, its financial resources, and its analysis of the benefits and liabilities of the available options.

What is a smaller college? The panelists suggested several alternative definitions. According to Bruce Alcorn, it is one with fewer than 2500 students and offering no degree higher than the bachelor. Vincent Swoyer suggested that size alone is not adequate as a criterion; a small college may be (at least for the purposes of this discussion) any institution that does not know how to use computers.

The Characteristics of the Smaller College

Swoyer suggested that the smaller college, whatever its definition, sees computing as a problem primarily of providing an educational resource, rather than for research. Its options are basically limited to some combination of these three alternatives:

- off-campus service(without time sharing);
- time-sharing service from an off-campus agency;
- a small or mini computer on-campus.

According to Swoyer, those people whose principal experience and interest have been with large universities and major computing efforts often lack an understanding of the objectives, problems, and financial structure of the smaller colleges. It is sometimes thought, for instance, that the position of the small college with regard to computing today is similar to that of the large university ten years ago. But this is not so; the difference is less in time frame than in purpose. In large institutions, computing facilities have been developed as a consequence of the need to support research activities; educational computing has grown up around this basic need. The smaller college must find its base for computing in a different place altogether. Computation is needed primarily for instructional purposes and must be supported in the way that educational facilities are supported in general. It is not based on research use or, except for very exceptional cases, on Federal grants.

Many smaller colleges feel pressure from students to support computing. Students entering college are increasingly arriving with pre-college computer experience. A recent report indicates that 13% of public high schools now use computers in instruction. In order to attract these students, it is necessary to have some form of computation for them to use. Another pressure is from the graduate schools. A primary intent of many smaller colleges is to prepare students for graduate study. In some of the sciences, this means students are expected to have computer experience.

Faculty experience provides a different kind of pressure. With administrators generally lacking a basis for making decisions with regard to computers, a few interested teachers can direct the entire course of operation at a small college, with the resulting installation biassed toward the interests of those men. It is important that a definition of the need must precede consideration of alternative ways for smaller colleges to do their computing. Once this is done, competent advice may be sought from someone who also appreciates the institution's financial position.

The SREB Project

In Bruce Alcorn's definition, a small college is one with fewer than 2500 students. By this definition, smaller colleges comprise 57% of all institutions of higher education but only 31% of the institutions with computers. They are responsible for only 6% of the funds expended for computation by colleges and universities.

The variety of options has increased for the small college in the last several years. This list is basically sequential in terms of costs and capability:

1. Off-campus computers, no terminals: Colleges use computers at other organizations by transporting data or users to and from the center.
2. Off-campus computer, terminals: Some colleges use slow speed terminals (e.g., teletypes) to a university or commercial system.
3. Cooperative use of Computer: A shared facility can benefit several small colleges located in close proximity.
4. Mini to Small computer on-campus: This is probably the most popular option in use today.
5. Cooperative use of computer, terminals: At the small college level, some college usually assumes leadership and sells access to the others.
6. On-campus computer with communications capability: This alternative provides a machine on campus with some processing capability and with the ability to act as a terminal to a large-scale machine.

Since 1968, the Southern Regional Education Board has been involved in an NSF-supported project on the use of computers for instructional purposes in small colleges. Three of these six options have been explored: terminals to off-campus computers (2), small computers on campus (4), and the cooperative use of a compu-

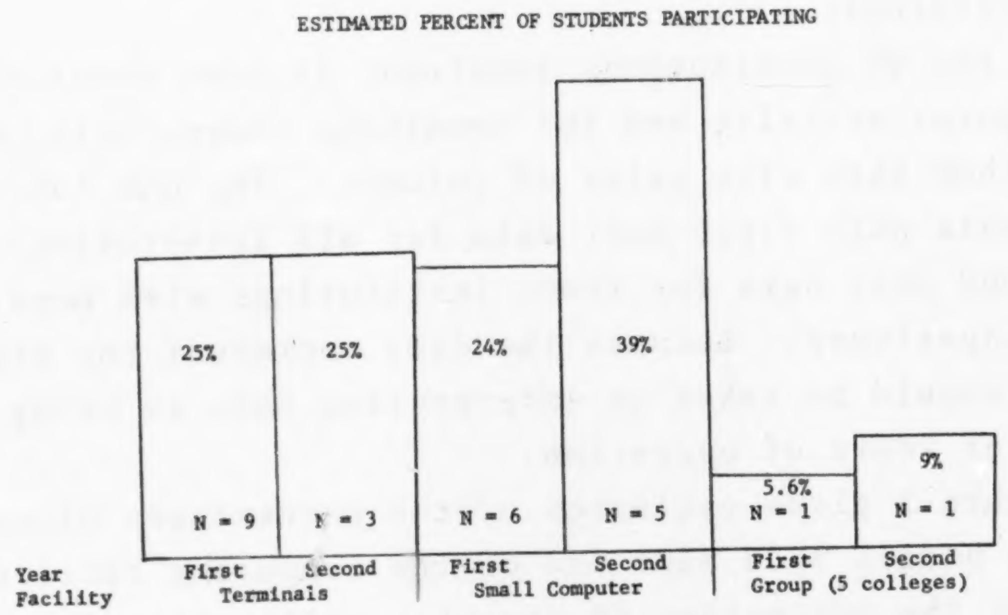

Figure 1

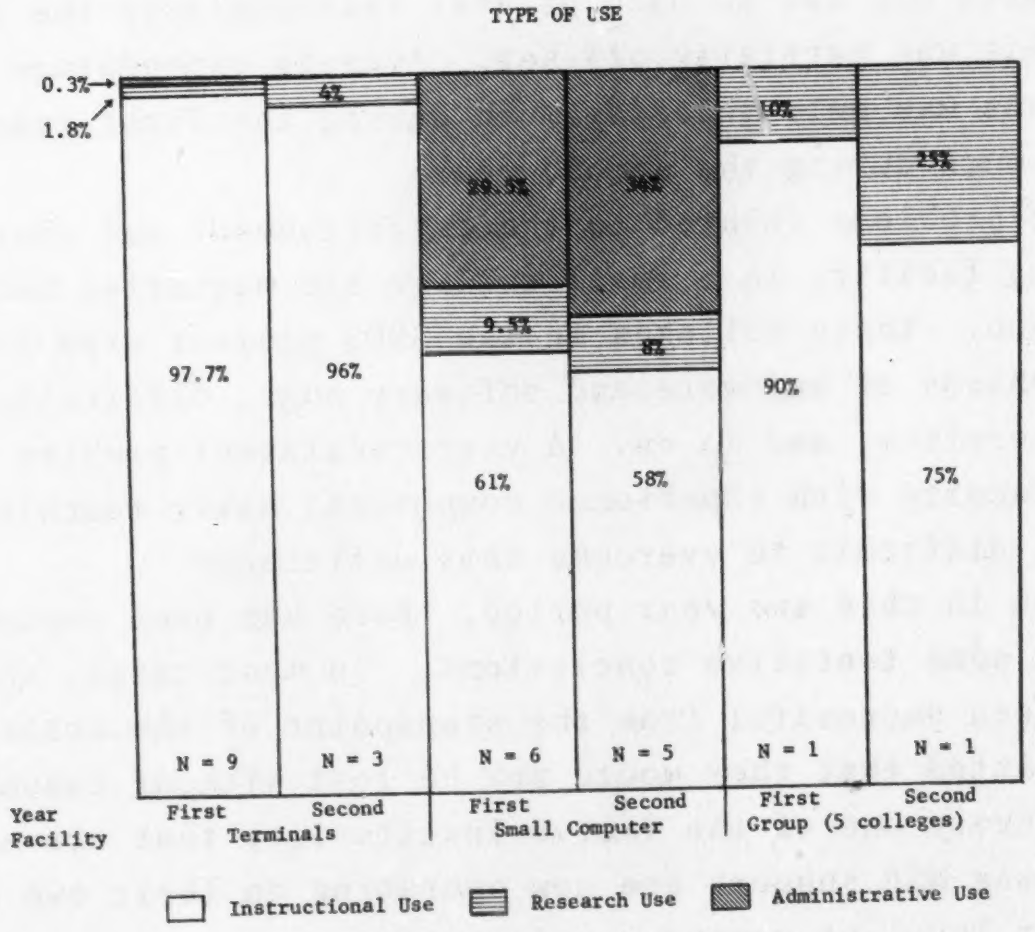

Figure 2

ter without terminals (3).

Of the 20 institutions involved, 13 have completed two years of computer activity and the remaining seven, only one year. The figures show this with pairs of columns. The one labeled "first" presents only first year data for all institutions; "second" presents second year data for those institutions with more than one year of experience. Because the data represent the start-up period, care should be taken in interpreting them as being indicative of later years of operation.

Figure 1 gives estimates of the percentages of the total student bodies that made use of the computing facilities. Figure 2 shows the percentage of computer utilization for instruction, research, and administration.

The institutions using small computers spent almost four times as much on computing as did those using terminals. However, student use was so much greater (particularly the second year) that this was partially off-set. Average expenditure for use per student was only twice as much during the first year and 1.4 times as much during the second year.

The problems related to the establishment and operation of a computing facility in a small college are magnified because of inexperience. Those colleges in the SREB project experienced the usual problems of hardware and software bugs, difficulty with vendor services, and so on. A very consistent problem was the lack of faculty with experience computers; heavy teaching loads made it difficult to overcome this deficiency.

Even in this two year period, there has been enough evidence to draw some tentative conclusions. In most cases, the project has been successful from the standpoint of the colleges; some have admitted that they would now be lost without computer facilities. Every one of the twelve institutions that are no longer receiving NSF support are now operating on their own at the same or higher level of computer utilization.

Institutions which are just beginning to use computers do need help in most areas, but especially in getting the faculty actively involved. The success of computing facilities is strongly related to the leadership, enthusiasm, and attitudes of those really in charge of them,the personnel making the important decisions.

Because of the shortness of the period of the investigation, and the very different characteristics of the institutions involved, care must be taken in evaluating the data. Costs per participating student are inflated as compared with similar costs at older centers. However, the total costs do represent good measures of start-up costs for the different types of facilities. Second year total cost increased 20-25%, while costs per participating student showed a significant decrease. As computer use becomes greater, the operation of the facilities becomes more efficient and unit costs will tend to level, probably during the third or fourth year of operation.

Further Considerations

Several further points were brought up by John Caffrey to broaden the context of the discussion.

In the smaller colleges, there is a tendency for academic and administrative computing personnel to seek separate solutions, a tendency that now appears to be disappearing at the larger institutions. In the smaller college, it may be that there is a greater efficiency in using special-purpose equipment to solve different problems, rather than trying to put everything together to justify a larger, more general-purpose computer.

At a smaller institution, the balance among the various kinds of use differs. Not only is there less research, but the ratios among the other uses also differ. Instruction in computing may be more important than instruction with computers, for instance. The computer is more likely to be an object of instruction rather than a tool of instruction for the present.

There are sometimes good arguments for an institution's going its own way. If it is more economical, or if there is some educational value in building its own computing resource (or its own power plant, for that matter), then an institution ought to consider doing so.

Many academic computer centers have a historical bias because the first person to agitate for a computer on the campus was a librarian or a chemist or a social scientist. This is particularly critical at the smaller colleges, with fewer personnel to rely upon for guidance. If a generally useful solution is to be achieved, someone must face this issue. It may take an authoritarian to get the various factions together.

The term "computer center" has stayed but the concept has changed; it need not mean a single, geographic location. It means centralized management and control of the computing function; this is not incompatible with geographically distributed hardware.

We are only at the beginning of the third decade of the computer era. By the next decade, computers will have grown in their usefulness and become necessities to colleges of all sizes. In another few years, all colleges may have to report their available computational facilities for accreditation. Standards will have to be established for the kinds of facilities that are needed to support various types of instructional and research programs.

The Mini-Computer

Something magical about "having your own computer" makes college people want a computer on the campus despite the arguments for other means of providing computing. There are reasons beyond mere prejudice, however, to prefer a small computer to a terminal. First, the presence of a computer on campus serves as a prestige item in attracting both students and faculty. Second, administrative applications are more easily accommodated by a small computer than by a terminal. Third, there is the important educational function: letting students learn by playing around, modifying systems, experimenting. They can do such things on a small computer but not on a time-sharing system.

Finally, in some cases there is no available service to provide precisely the software, systems, and services the college needs. In these cases, a college must buy its own computer to create these services.

Cost comparisons of time-shared service and small or mini-computers are hard to make. In the SREB project, the cost of a terminal (with staff, computer, and communications charges) was about $18,000 per year. A mini can be bought outright for that much money. But the usage figures that might influence the interpretation placed on these numbers do not exist: time-sharing systems have elaborate accounting systems but small computers are usually managed very informally.

For some institutions, the best solution is to go both ways at the same time: a mini on campus to do the things that can be done most economically and effectively that way; and, some access to a larger system for the cases where the mini- is awkward or just too small and slow. In some cases, these capabilities are combined in a single machine, which has stand-alone processing capability and also can be used as a remote job entry terminal.

Time-Shared Services

Time-sharing can offer a lot more to the user than raw computer time. He has available to him the extensive libraries and the expertise of a large staff. Ultimately, the time-sharing vendor is in the business of providing service and not machinery. Still, in some cases it has to be argued that libraries and staff are unnecessary and expensive additions. If the computer time is to be used solely to teach programming and to do science and engineering calculations, the mini is a cheaper alternative than a more elaborate system.

Software

Perhaps, it was suggested, the discussion of the relative advantages of time-shared service and a mini-computer is focussed in the wrong area. It is easy to buy computer time almost anywhere. What is hard to find is software. Instructional materials and administrative systems are both hard to acquire without going through the expense of building them yourself.

Yet some transferable systems exist. There are a few proprietary packages in the administrative area but people have been slow to accept them. Instructional software (problem sets and curricular aids) does not exist, or is virtually inaccessible. Colleges are not aware of what is available and how it could be adapted to their needs.

On the other hand, a program that does more or less what needs to be done is not therefore universally applicable. In order to use a ready-made program, the college's administrative procedures may have to be altered to match the program. This may, in the long run, be more costly than constructing a new program. Adjusting the college to match the system may be the tail wagging the dog.

According to Robert McConnell of Union College, administrative applications are being produced for a group of New Jersey State Colleges to be run at a centralized facility. The program package produced by a commercial software firm has been unsatisfactory so far. Individual colleges are making modifications to customize the system to their own requirements, which makes the situation much more complicated. The turnaround time is bad and there seems to be no recourse. One of the advantages of having your own computer is that you can adjust your priorities to reflect your own interests and values.

People who have used software developed by someone else and found it unsatisfactory are very vocal. They let everyone know what a bad solution to the problem the software is. However, people who develop their own systems and find them to be unsatisfactory are not so anxious to publicize the situation.

Making Decisions

How much should a college spend on computing? This is a question of priorities and of educational goals. College presidents, when presented with something that appears to be a luxury, point out they cannot afford it. However, they have a way of being able to find the money for something desperately needed. If computers can be shown to be necessary to the quality of education to which the college is dedicated, most colleges can afford the computing they need.

Where should a college obtain computing? The college should begin by looking for the kind of service they want. If a single supplier cannot be found, the college should consider breaking up the requirements and satisfying some of them in one way and some in another.

How can a college assess the quality of service they deserve? Many users find lots of problems with their service but feel they are probably getting the best they can expect and do not complain. One good method of learning about the quality to expect is talking to other people with similar problems and different solutions, evaluating the alternatives againist one another.

What sources of information are there to help a college get started? First, the reports of the various regional networks provide some information about their offerings and the costs. Second, do not take the advice of anyone who stands to profit from your decision: manufacturers, vendors, salesmen. Third, visit other institutions that are like yours in size but are a step ahead in planning. Fourth, the Association for Computing Machinery has an Education Committee and a consultant program, in which the college pays only the expenses and the ACM pays the consultant's fee. Fifth, try to get some computer experience built in when you hire new faculty. Sixth, give the faculty the time and the opportunity to learn and to change their curriculum.

Where does the money come from? From the same sources that the money comes from for other instructional resources. Some colleges have paid for student computing through lab fees. Donations of computer time from local industry is sometimes a possibility, particularly if the industry depends on the college to provide computer-trained manpower. Sometimes it is possible to get a donation in order to purchase a computer. If the college is in earnest, it will find the money for computing somewhere. But the idea and the will have to come first; the money will follow.

Ultimately, computing is an educational resource and must be planned and paid for in those terms. It has to compete with other alternatives. The user must make the decision on what other possibilities he is willing to postpone in order to get his computing done. The fundamental questions are finally educational. How much computer education is important? For which students? Once this decision has been made, the other questions can be asked and answers can be found.

Special Topic 9: NATIONAL NETWORKS

Chairman: J. C. R. LICKLIDER
Director of Project MAC
Massachusetts Institute of Technology

JOHN C. LEGATES
Executive Director
Educational Information Network
EDUCOM

RICHARD NICHOLS
Vice-President for Marketing
AT&T Long Lines

LAWRENCE G. ROBERTS
Director
Information Processing Technique
Department of Defense

Academic computing seems to be entering a new era and many institutions find themselves reexamining objectives and reevaluating alternatives. One of the significant new alternatives appearing is the national computer network. The ARPA network is the first attempt to develop a national system.

Licklider referred to the current ARPA network as a bridge into the future. His picture at the far end of the bridge is of teams of research people located at different universities working closely together. They work at desks that are really computer consoles. They read reports and journal articles through a library system which is part of the network. They cast their theories in the form of models and run these models on computers best able to handle them.

How would a national network function? What would universities use it for? What would it be worth? What are the obstacles to its development? There may be problems which cannot be solved in a reasonably short time. It may be the next century rather than the next decade before the bridge is complete. Yet it is a fantastic concept with enormous potential.

The panelists undertook to discuss different aspects of the present network and its future: its value to the academic community, current operations from the point of view of both ARPA and the member universities, and communications problems.

The Universities

John LeGates suggested some reasons why universities might find such a national network interesting. There exists, he said, a well-known mismatch between computers and users. This is true among all user communities but it is particularly the case with regard to academic use. The mismatch consists of a number of elements.

There is enormous duplication of software and personnel. Lots of people are doing the same jobs at different places. They are creating programs and systems that perform essentially the same functions but for different machines in different places. They lack any means of sharing or distributing their products. A network is an opportunity to create a vehicle for such distribution and sharing and is thus an opportunity to save time, money, and talent.

Another consequence of the current organization of computers is that some computers are not used to capacity because they are larger than the user community needs. Thus the users pay a high job rate. Computer software is developed at one location and only a few people use it because it is neither known nor accessible to potential users at other locations.

There is also distorted utilization. Many people are forced to use whatever happens to be available, even though it is not ideally suited to their needs. This applies both to hardware and software and can raise the real cost of a job as much as 1000%.

Finally, economy of scale is not achieved. Many small and medium sized computers are being used where access to large computers would be both more convenient and more economical.

These problems exist under the current one campus/one computer pattern. A national computer network will provide some assistance in each of these problem areas.

First, as the need for computing grows on campus beyond the capability of the available hardware, it may be more convenient and economical to direct the overload over the network to some other machine with available capacity, rather than acquiring additional equipment on-campus.

Second, the network will offer a range of computers, more than could ever be available in one place. A user will be able to select the right machine (with the right software) for the problem he has to solve.

Third, the network will provide access to specialized resources: programs and data banks will be available to widespread, national communities of users.

Fourth, it will provide an opportunity to universities to market their surplus capabilities.

Fifth, it will provide a greater efficiency and economy.

The ARPA Network

Lawrence Roberts described the current ARPA network. It is designed to handle, without degradation, all of the input and output from each computer and also all of the intercepted input and output. Currently, messages from any of the nodes can be delivered anywhere in the country in .1 second. A stream of 8000 bits can be delivered in .3 second. The system is designed so that there are always two possible paths from any point to any other point, thus providing greater reliability.

Compared to the reliability of the computer at the users end, the error potential of the network is trivial. The undetected error rate is on the order of 10^{-12} or less than one per year in the current situation.

Hardware and communications costs are significant aspects of the system. The large IMP, able to handle many host computers and a large share of the throughput of the system, leases for $40,000 per year. The smallest IMP handles one or two host computers and not quite so much throughput. It leases for $20,000. This is the most commonly used IMP and this figure may be taken as the basic cost of the communication terminal. The cost of communications themselves must still be added. Currently, these costs are prorated among the 23 node systems and result in a cost of about $36,000 per year per node. Communication costing methods are going to be changed as soon as possible to a shared cost per bit, the rate will be on the order of 30¢ per megabit.

A gradual evolution and change the system will take place over the years. In the first few years, Roberts believes the most attractive aspect of the network will be the sharing of hardware services. Currently, universities have to operate computer facilities: this is the only way they can satisfy the need. The network will provide an opportunity to choose other methods. Consider this typical case. An institution needs more computing power to satisfy its users. If a new and larger computer is installed, it must be a compromise between all user requirements, not usually being cost-effective for anyone. Instead, the institution can join the network and allow the overload to go out to other computers. This solution will probably be two to ten times cheaper, even with communications costs, than an expansion of the on-campus facility. It will also provide a range of services that the individual computer center cannot match.

Probably about two years after the network is well started, as it grows in size, with more nodes and more computer systems hooked into it, the second stage in its evolution will begin. Roberts sees it as an era of data base sharing and the principal value of the system to users will be the availability of a national library of data bases.

Roberts believes the third stage will be one of software sharing. He feels this stage will be more difficult to get going than data base sharing and will take another two years. After about ten years from the beginning, Roberts expects the appearance of textual services: teleprocessing and library services; office paper-work maintenence, and so on.

Communications

ARPA and American Telephone and Telegraph have been discussing the future of the network and their possible relationship in its operation. AT&T is considering taking over the operation of the network as a common carrier. According to Richard Nichols, however, there are special problems created by the peculiar nature of the ARPA network. For example, the design of the IMPs creates a special security problem since on its way from the sender to the recipient, data pass through an IMP controlled by and accessible to a third party, who might obtain access to it. The carrier traditionally has responsibility for the security of transmission. The problem is not insoluble, but it will take time to find a solution that is acceptable both technically and economically.

If AT&T decides not to accept responsibility for the communications operation of the network, it might be run as a federal system, but this raises a question of how it could function as a common carrier and sell services. AT&T will in no case offer any more than communication services, including the IMPs or their equivalent and the intercity facilities. It has no interest in managing the organization as a whole, or in building the superstructure that brings all the members of the network together.

The User

Steve Crocker presented a picture of the network from the point of view of one of the node institutions. A working group consisting of representatives of all of the nodes is concerned with modifications to the several computer operating systems necessary to allow them to use the network. The work of the group has been slow, in particular, because of three problems.

First, the interface between the communication network and the operating systems is more sensitive than had been anticipated. Second, documentation is difficult. The user/computer interface is more critical and difficult to manage when the user is far away and cannot ask a question when something goes wrong. The documentation and literature provided to the user must be complete, up-to-date, and comprehensible at a distance. Third, the computer centers now on the network differ considerably. For some, joining the network has been their first experience with customers not members of their own university communities. There have been difficulties in establishing policies for a mission essentially unrelated to the university's mission. There is difficulty in knowing what priority to give the network in developing the system modification to get started. Once started, it is not clear what the relative priority of the off-campus user should be. The computer center director must expand his vision and view his user community as distributed.

These three factors are slowing down the development of the network, but the interaction and cross-fertilization of ideas and interests of the staffs of the computer centers has been considerable. Most of the benefits predicted for the system are still in the future. There has been one example of a spectacular saving at UCLA because of the network. Later this year and in 1972, Crocker expects such events to become an almost daily occurance.

Reliability and Service Quality

Computer reliability has improved greatly in the network, from ten system errors per day to about one every two weeks. But some systems are still better than others because of personnel and other reasons. This is a problem users will have to face. There may have to be reliability controls within the organization.

Computer centers without competition have little impetus to improve reliability. With the network, the user will be able to change machines if he is not satisfied. If the system does not perform for him, he will take his business elsewhere and will naturally prefer the system with the highest reliability, other things equal.

A serious problem occurring in the switching of computers relates to the availability of files. If the computer that contains a user's files is down, it will not do him any good to have another computer available on which to run his programs. The ARPA project is trying to find some way of backing up files, perhaps by a very large storage system for the general use of network users. Laser memory will soon be economical enough to provide cheap and permanent storage in the network and a user may be able to dump his files there and leave them indefinitely.

Very few computer centers in universities today are currently organized to service a broad community of users. They are accustomed to give preferential treatment to their own in-house users. There may be a need for some minimum standards of operation to qualify a computer center for acceptance to the network. In the environment of the network, hosts must be unbiased and extremely well-run organizations if they are to serve the users.

The competitive market may be sufficient to control the quality of service from the nodes. Commercial time-sharing service companies on the network will be very sensitive to user satisfaction and will keep other suppliers on their toes. There are always some users at a point in their work where they can change services, if they are dissatisfied.

Not all host computers, however, will be primarily concerned with rendering a service. Some will be primarily research vehicles. Their users will not have competition working for them. A procedure of guaranteeing quality and level of service may be one form of protection for the user. Public records of user comments and criticisms may be another.

Freedom of the user to select the service that suits him best will be a powerful force. If the money is given to the user rather than the computer center, then it will gravitate to the organization that provides the most cost-effective and reliable service. The on-campus computer center no longer will have a monopoly. If it cannot compete, it will disappear. In fact, the whole concept of a university-operated computer center may become obsolete.

Some changes seem inevitable. In a few years, there will probably be fewer medium-size machines. Computers will be either very large for cost-effective service to a large community of users or very small for service to a single user or a small group of users. There will also be more specialization.

Rather than trying to provide a broad range of services, some computer centers will specialize in the things they do best, where they can provide better or cheaper service than the competition. Those computer centers that cannot be competitive on a broad range of use and that cannot specialize will simply disappear.

Organization

ARPA started the network but has no interest in managing it. Its interest will continue to be in funding new research facilities and promoting new ideas; It is anxious to get out of the position of administering either the communications or the use by universities. AT&T may provide communications, but it will not take on the responsibility of building a management superstructure. Some organization will have to take on this function. EDUCOM has been mentioned as a possibility.

EDUCOM has been supplying information about the network to universities. Henry Chauncey, President of EDUCOM, wrote to the presidents of all EDUCOM members and some other large institutions, informing them about the network and asking for an expression of interest. All of the institutions responded, about 90% favorably. Of these, about 10% said they would be interested in membership immediately and 40% expressed an interest in joining in two to four years.

If the network is to be successful, there must be good standardized documentation. Thus some organization must develop standards and examine and test the documents before they are distributed to users. EDUCOM has offered to assume this responsibility.

In the 1966 EDUCOM network study, one of the major advantages seen for a network was to bring together people from various professional groups who wanted to collaborate. The network can encourage communications among its educational users. EDUCOM might be able to help. The problem of getting people onto the network is more one of organization than of money.

Special Topic 10: LIBRARIES

Chairman: ROBERT HAYES
Vice President
Becker & Hayes

FRED HARRIS
Director, Computation Center
The University of Chicago

FRED KILGOUR
Director
The Ohio College Library Center

RONALD MILLER
Director, NELINET
New England Board of Higher Education

Interest in the relationship between libraries and computing has largely been in two areas: the use of computers to support the clerical functions in the library; and the use of computers to process large data bases. The latter area has involved such bibliographic data bases as those of the Library of Congress or the Chemical Abstracts; but there are also numerical data bases, critical tables, and even, in the future, text tapes. These may be seen as extensions to the services provided by both agencies, the proper relationship between them is a topic of considerable importance.

With regard to clerical processing, it seems after careful review that much of the promised economic justification for computer use in the library may simply not exist.

The actual economic value of computerization is difficult to prove -- especially if one considers the amortization of the costs of development and file conversion.

As a third topic, Dr. Hayes suggested the operational relationship between the library and the computing facility. The clerical use of the computer relates more to the administrative than the academic type of computing; yet many of the procedures are better handled at an academic computing center.

University of Chicago

At the University of Chicago, automation of library functions began in 1966 with an NSF grant. The overall concept of the automation plan is that of an integrated, computer-based bibliographic data processing system. Phase I (which is now operational) is designed to handle record generation, processing, and maintenance. This involves operations associated with acquisition, cataloguing, physical processing, catalog maintenance, bookbinding, labelling, and distribution. With a single bibliographic record, initiated either from MARC tapes or from input from 1050 terminals in the library, the information processing functions of the entire acquisition process can be carried out routinely and automatically.

The second phase of the plan is now under development. It involves the investigation and design of a data management system to serve as the data base acquisition and control mechanism. They are looking for a general-purpose management information system. Hopefully they will be able to piece it together from available commercial systems; if this is not possible, it will have to be custom-built.

The third phase will be the application of this system to additional operations within the library, such as circulation, catalog query, and so on.

Fred Harris, who presented information on the situation at Chicago, made it clear that he is not a librarian but, as Director of the Computation Center at the University, a supplier of services to the library. A close relationship exists at Chicago between the center and the library. The library has always used the research computing facility and has never had a computer of its own. The Director of the library is an active member of the Computer Policy Committee, the Executive Committee, and the Long-Range Planning Subcommittee. Thus the library is able to be closely involved with Computation Center policy and planning.

The organization of the operation is as follows. The library has its own systems development staff, consisting of library analysts, programmers and systems analysts. In addition, it also relies on the Computation Center for programming, systems analysis and, of course, machine services.

Financing is a major concern at both the library and the Computation Center. System development is funded in part by grants and contracts and in part by University funds. Operational services are budgeted out of University funds. There is also a third source of support: a slice of the Computation Center's deficit. For some time the University has supported its Computation Center in excess of demand usage; to avoid wasting their resources, the excess capacity is used as a sort of extra budget allocation. Although this capacity is allocated primarily for instructional purposes, some of it goes to the library for operational purposes.

The library is particularly interested in establishing the cost-effectiveness of the automation project and has made cost-effectiveness comparisons an integral part of the development effort. One of the concerns of the library has been the appropriateness of the pricing mechanisms of the Computation Center. A second concern is the absence of comparable performance data on the manual system.

The library and the Computation Center expect a gradual evolution of automated systems to hinge on three factors: the intellectual questions, the economic issues, and some technological questions. The path the University has so far taken has resulted in a conservative view, based on finding answers to some rather hard questions of the priority use of funding and manpower in order to spend the effort in maximizing output.

Ohio College Library Center

Fred Kilgour began his presentation by defining a "comprehensive library system" as one which includes the users of the library as well as the internal operations. Thus, his view of the usefulness of the computer is very broad.

He distinguishes three possible organizations in the relationships between libraries and computers:

- the library has its own dedicated computer;
- it uses the university computer;
- it uses a regional system dedicated to library operations.

The library with a dedicated system usually has a medium-size or small computer. Such a computer has a number of limitations; in particular, the small memory cannot support the manipulation and management of large files of information. Thus it seems that the dedicated computer in the library -- except for the very largest libraries -- restricts the possibility of taking full advantage of the power of computers.

The use of the university computer usually means access to a more powerful machine and more memory capacity. But this will not solve all the libraries' problems. At the University of Chicago, for example, the library is unable to maintain its entire MARC data base in the secondary storage available in the Computer Center system. There may also be problems in the relationship between the library and the center, with regard to staff and the quality of service. The computer selected for the computer center may not be the optimum choice for the use of the library. Older machines with 6-bit bytes or machines without list-processing language capability, make library use difficult.

The regional library center has a number of advantages over both the institutional center and the dedicated computer. First, the computer can be selected essentially for library use. Second, the operations and quality of service can be oriented entirely to the requirements of libraries. A regional center means access to all of the resources of the libraries of the region in one central location so that duplicate operations among libraries can largely be eliminated. Finally, there are important economic justifications. With such a center, it is possible to lower the rising cost-per-student curve and to achieve net savings in operational costs.

In the case of the Ohio College Library Center, an on-line cataloging operation is being constructed. It will include the generation and operation of a union catalog with the facility for interlibrary loans throughout the State of Ohio. The cost of this operation is supported by library funds and also by grants and contracts ($90,000 from USOE; $14,000 from the Council on Library Resources; $25,000 from other sources). The library contribution can be amortised by the savings at the libraries themselves, in a period ranging from 4 to 8 years. As for net savings, it is now predicted that by the second year, these will amount to $400,000 at the 50 institutions involved.

The $400,000 net savings is based on a gross savings of $1,000,000. In order to realize it, the libraries must reduce their personnel cost by one million dollars. Making savings in this way is a new experience for libraries and techniques will have to be discovered for working this out. The $600,000 annual cost of the system is broken down as follows:

$132,000	personnel and operation of the center
195,000	computer and related equipment
120,000	communications
149,000	70 terminals at the libraries

Library Survey

Ronald Miller presented the result of an informal survey he had made of six academic libraries of different sizes. None of them has its own computer. They all use services from a university-wide computer center.

The computers at these institutions are all IBM 360's ranging from Mod 50 up. Most of the terminal connections are remote job entry, ranging from 2260's and 2741's to Datels and 1030's. By and large these are not selected on the basis of library requirements, but for all campus users. MTST, while not a terminal, is being used at several campuses for text processing and editing. Languages used seem to be COBOL or PL-1, with some subroutines in other languages.

There is roughly a 3-year cycle in computer center stability. Every third year there is a major upheaval that the library has to contend with and over which it has no control. This upheaval is due to the acquisition of a new computer or updated memory and results in disruption of service.

Libraries tend to have very little real power over computer center management. In one case Miller presented, the technical services director of the library is chairman of the computer advisory group. However, this is a rotating chairmanship; and the committee has little real power simply endorsing policy and serving as an interface between the center and the faculty.

There does not seem to be any relationship between the degree of power of the library in these matters and the size of the institution or of the library. There does seem to be some improvement in the relationship between the library and the computation center over time; a history of joint activities makes for smoother current operations.

The most important area of computer interest in these libraries is acquisitions. One of the largest spends $80,000 annually for computer services in acquisitions processing. Other areas of interest include serials, holdings, and other basically list-producing programs. Although claims of compatibility are sometimes made, very little thought has been given to relating these programs to future data-base systems. Circulation control systems have been built, but without plans for integration with other library systems in the future.

There is little planning for data base utilization except for MARC. One campus is considering handling Census tapes, but in an archival and advisory capacity rather than by processing them for users. In-house data bases range from circulation and acquisition to off-the-shelf software packages for file generation. The data bases that exist are usually operated as separate and independent systems.

The interest of libraries in combining into regional groups is dominated by the fact that each library that has advanced somewhat in producing its own automated system does not want to make concessions; it wants to be the center of any group that is formed and to provide its services to other libraries. Institutions with well-developed in-house capabilities and systems staffs tend to resist joining unless they can be assured some kind of control.

In summary, computer use in libraries is not a function of the size of the computer center or of the library but of the service policies on the campus and of the length of time the relationship between the computer center and the library has been established. One of the best relationships is at a very small school, where there are good personal relationships among the people and where they seem to understand one another very well. By and large, libraries do not seem to get bad service from their computer centers. The fear of being low man on the totem pole seems to have little foundation in actual fact.

As for the future, Mr. Miller sees a further blending of techniques, particularly more microfilm use, possibly blended with computer retrieval.

NELINET

Several questions were asked about the current status of NELINET. It involves a PDP-10, which is service bureau operated and serves 20 member libraries. The products are similar to those presently produced by the Ohio College Library Center but in a service bureau environment. The programs were written in machine language because of concern for operational efficiency rather than developmental cost. It was believed that machine language programming was the best means to achieve this end.

The currently operating package is called the "cataloguing products service subsystem" -- subsystem because it is part of a conceptual whole which has not yet been realized. The products are tailormade catalogue cards for users, produced as the result of the receipt of teletype tapes from participating libraries. Any number of cards or book and spine labels can be produced for each title. An ALA print train will be used at 8 lines per inch beginning September 1971. A potentially interesting by-product is the data base itself -- which can be considered a machine union catalogue for those users who have taken advantage of it. However, currently the only access to it is by requesting cards from it by LC number.

Data Bases

Hayes asked for comments and experiences in the collection of data base tapes by libraries. He pointed out that there have been archives on some campuses that have been data-base related. Data base tapes have sometimes been acquired by computer centers, and there are a number of census tape processing centers. However, the role of the library in the acquisition and use of data base tapes -- indices, abstracts, and numerical data -- is not yet fully defined. This area, even more than the technical processing of library data, raises important questions of charging, since it involves faculty and students as well as the library and the computer center.

Mr. Miller suggested that the utilization of data bases has so far been largely in the commercial domain, where some agencies have been able to generate a number of marketable products from the tapes. In the academic area, one of the first efforts of UNITEL (the joint Harvard/MIT corporation) is to provide some services from Census tapes. About 30 researchers at Harvard and MIT are participating in a pilot project using these tapes. The IIT group in Illinois produces SDI from a half dozen data bases. In many cases data bases are being combined in services that are not related to libraries at all. At the University of Connecticut, for instance, the New England Research Application Center (NERAC) provides batch searching capabilities, which are marketed by the library to faculty and staff, as well as several commercial groups. Some 22 data bases are employed in the NERAC system.

John McGowan, of Northwestern University, suggested a distinction between data bases that are basically bibliographic (such as Chemical Abstracts) and those that are not. The former fall within the interests and responsibilities of the library. The latter constitute a very different case, however, with little relationship to bibliographic concerns. Using the Census tapes means having people competent in computer programming and statistical analysis, a responsibility more closely related to the capabilities of the computer center than the library.

According to Judith Rowe, the Princeton University library is highly involved in the acquisition of data bases, contributing to the acquisition of Census data and to the operation of the joint Princeton/Rutgers Census group.

The Princeton library considers these data bases a legitimate part of the Library's resources and supports their acquisition and use.

A considerable concern at Princeton has been in getting data bases catalogued so that their existence is known to library users. Even an inventory of data bases on campus may be difficult. The number at a large university is probably very great. At UCLA there seem to be about one hundred that could have reasonably broad utility. NELINET has begun a catalogue for the New England region.

In general, the tendency seems to be that the library pays the cost of acquiring the tape. The user pays the cost of processing it. At Northwestern, however, the Library bears all the costs of Chemical Abstracts, paying for the acquisition of the tapes and the computer processing, and also supplying a full-time staff member for those purposes. Northwestern is concerned about such ancillary questions as educating the user population and the support of graduate students.

These services are very useful tools; but, they are also very expensive. Most institutions must ask whether their value is worth their cost. In industry, in contrast, it appears that such tools are used liberally. Some rather small special libraries subscribe to as many as four or five tape services, using very sophisticated SDI profiles. In these cases, it is clear that the services can be cost-justified on the basis of an increase in productivity on the part of staff members.

There are two reasons why the example of these libraries is difficult for university libraries to follow. First, a special library has limited interests; it can collect everything in its field, use all of the services available in that field, and still get by with limited costs. A general research library must service all of the sciences, the social sciences, and the humanities. The costs can become astronomical if maximum service is to be provided for all areas. But the alternative -- doing it for only a few areas -- is not possible either. Second, increase in productivity on the part of the faculty is hard to prove and hard to justify to a legislature. This is not the kind of saving which can ever be seen in dollars.

The future for such services, so difficult and expensive for individual libraries to provide, is perhaps more logically to be found in the regional center, where there are more users, where more combined profiles are possible, and where costs per user can be reduced. Experience is so sparse, however, that optimum size is not well understood. Nor, for that matter, can one say with any confidence how big a "region" should be. It may be that national centers for different disciplines will be a more satisfactory solution.

The Regional Center

Of the three mechanisms for providing service to libraries enunciated by Kilgour, the regional center appears to be the most promising. It increases the resources available to the participating libraries, allowing them to do more work at less cost. However, cost savings are a very nebulous area. It is difficult to compute the real costs of either the automated system or the manual one it replaces. At one institution in New York, the library was able to report that it had reduced its staff by 2 as the result of automation; however, at the same time the computer center increased its staff in order to service the library.

Ultimately, one must talk about benefits beyond the financial ones. The goal is to put into the hands of the user the information he needs, when and where he needs it. This is being done to some extent in bibliographic information now. Other areas will follow.

In the Ohio system, a simulation has revealed something about the nature of the use that would be made of a comprehensive system. In this simulation, it appeared that only 5% of the utilization was by library staff 95% was service directly to the user. Individualized services are provided when and where the user needs them and in the form in which he can best use them. The big savings and major services are ultimately to the user.

Special Topic 11: MEDICAL COMPUTING

Chairman: RUTH M. DAVIS, Ph.D.
Director
Center for Computer Sciences
and Technology
National Bureau of Standards

RALPH CHRISTENSEN, M.D.
Lister Hill Center for
Biomedical Communications
National Library of Medicine

AUGUST SWANSON, M.D.
Department of Academic Affairs
Association of
American Medical Colleges

The Discussion Session on Medical Computing was invited to consider the appropriate role of medical schools in introducing their students to the application of computers to medicine and health care, and the alternatives if any. It also was challenged to identify the most important computer applications to health care that appear to be realizable within the next three years and to discuss solutions to the problems associated with providing an appropriate and practical means for giving medical students an appreciation of the computer as a tool in preparation for their medical careers and their future.

Dr. Davis, Chairman of the Panel, opened the session by pointing out that there are in the United States today 103 medical schools. They represent approximately 4% of the total number of colleges and universities in the country. Most of these schools are associated with medical centers and universities, and thus almost all have access to computing facilities of some kind. Relatively recent data would seem to indicate that approximately 70 of them not only have access to such facilities but are making use of this access in one way or another.

Since these 103 medical schools constitute a funnel through which virtually all practicing physicians in the United States must pass, collectively they provide a unified point of contact to an entire profession at which an appreciation of and familiarity with the application of computers could be introduced. If students received some training in the use of computers in medicine and health care during the four to six years that they spend in medical schools, practically all physicians entering the field would have the capability of utilizing this additional tool in their profession.

Computers and Medical Care

Dr. Ralph Christensen suggested that it is not possible to talk about the role of computers in medical education without looking first at the role of computers in medical care; they are aspects of the same situation. It is useful, therefore, to begin a discussion of computers and medical education with a quick review of the uses to which computers can be and are being applied in medicine generally.

Practice Management and Billing Systems. These services are now being provided by banks, medical societies, drug houses, and computer service companies. A recent count identified more than 40 such companies and agencies. The costs for these services are roughly equivalent to conventional accounting costs.

Automated Patient Histories. In order to conserve the time of the physician and other staff (and to develop a file of legible histories), computer-based patient histories are being developed. One of these is the Searle Medidata system, which has been used by physician groups and hospitals.

Automated Multiphasic Screening. The use of computers in health testing allows the physician to see large numbers of patients; it is particularly valuable in preventive care. At present, there are 122 active and planned multiphasic screening systems in the country. These are operated by private corporations (27), government (29), hospitals (20), and other medical institutions (12). Most of these systems provide standard batteries of tests for a fixed fee; this fee is variable but is usually around $33.

Computer-Assisted Diagnosis. Mead Johnson has developed a program in pediatrics in this area, but it was recently withdrawn from the market. They announced a new one, however, in the internal medicine area.

Medical Records. The AMA is in the process of developing a system of medical records. Robert E. Robinson's 5-year study of this topic for Bowman Gray Medical School will be completed in 1972.

Computer and Medical Instrumentation. Computers are used in the physiological monitoring of the critically ill. The 1968 Directory of Regional Medical Programs listed 57 projects monitoring coronary care patients.

A different type of use of computers in medicine is exemplified by AIM-TWX, the National Library of Medicine on-line bibliographic search system. This system was developed in conjunction with an abridged Index Medicus and is now available to any users anywhere with access via TWX. The service is free; however, the user must pay his own line-charges and terminal costs. It is hoped that it will soon be available nationally on a local call basis.

In order to demonstrate its usefulness, Dr Christensen conducted a search on the subject of education, computers, and medical care. The search revealed 1592 titles in medical education; 537 on computers; 156 on patient care planning; 50 on computers and medical records. After the request was modified, a list was finally arrived at which had 109 fairly reasonable citations. The complete list of the citations was not printed on-line but was delivered by mail, 36 hours later. The entire process took about 23 minutes at the terminal and used 20 seconds of central processor time.

AIM-TWX is an example of a system that can provide supplemental medical information to physicians on demand. If systems are to be used by physicians, they must have the following properties:

- be relatively simple to operate;
- be consistent and reliable;
- provide real-time response;
- provide immediate evaluation of results of search;
- be convenient;
- cause only minimum disruption of other activities.

A computer system that possesses most of these characteristics can be introduced into medical education and health care, particularly at the level of the medical student and resident. Without these characteristics, such a system will probably not be used.

Medical Education

Dr. Swanson began his talk by asserting that physicians must become accustomed to the computer, eventually finding it as natural a part of their resources as the stethoscope and the pencil. Medical schools must assume leadership in introducing computer technology to the next generation of physicians, for the computer will be an absolutely essential tool in future medical management. Presently most medical schools are teaching methods of data collection based upon principles developed during the first 25 years of this century. The recording of these data is still dependent upon handwritten records, and integration of data collected by physicians, nurses, and laboratory tests in an easy-to-access system is essentially nonexistent.

The transition from this chaotic mode to a totally computerized data retrieval and decision-management system cannot be achieved in one giant stride. Notable experiments in computerized medical records systems such as the Problem-Oriented Record System developed by Larry Weed and the Professional Audit System linked to Ann Arbor, Michigan, are now in progress, but these currently affect only a small number of individuals who are directly involved in them. Significant impact is yet to be made by these systems on the physician's role in future medical practice.

The lack of computer sophistication among professional medical faculties and students is a major deterrent to the rapid and effective application of computers both to data storage and retrieval systems and to learning systems. The efforts associated with understanding computer logic and learning computer languages are major obstacles. Medical faculties and students are generally hardpressed for time, and unless there are clear rewards for exposing themselves to a new technology, they are reluctant to invest time in the basic education necessary to adapt a new technology to their needs.

In many instances, faculty members have had very unsatisfactory experiences with their first ventures into the computer world. The relative capabilities of the entourage of technicians, managers and scientists housed in a computer center are *obscure*, moreover, the effectiveness of members of the faculty is often hampered by bad advice from professionals who have not researched the faculty's real needs and goals.

The situation is further compounded when the potential user returns to the computer center to seek further advice and aid only to discover that the person with whom he had been talking had moved elsewhere in the helter-skelter game of musical chairs which characterizes this field.

Presently those members of medical faculties who can comfortably interface with computers are few, and most of them are using computers for limited goals related to their personal research. They haven't the time, ability, or inclination to transfer this knowledge to computerized education or to computer-based management systems. A few students become skilled in interfacing with computers during their undergraduate years, again usually in a limited area. But they find little in medical school instructional programs which continues to develop or broaden these skills.

It is clear that there is a great need for the rational introduction of competent computer technology into medicine. It is equally clear that the degree of technological and conceptual sophistication characteristic of experts in computer science is not matched by an equal degree of technological or conceptual understanding of computers by our medical faculties and medical students. Until this gap is reduced, major advancements in computer applications are not likely to occur.

What are some of the strategies for attacking this problem? One might be the promotion of introductory courses in basic computer logic into all medical curricula. This must be taught in a context relevant to medical problems or it will be poorly accepted by students. Another strategy might be to develop computer-based instructional programs in disciplines pertinent to basic medical sciences or clinical medicine. Experiments in this area are in progress and should be expanded. However, students learning to interface with a computer in this context may or may not learn much about the tool itself. A further strategy might be to develop computer-based data storage and retrieval systems for medical records. Again, students in interfacing with such systems may or may not learn about computers. How much do students learn about computers when using a mark-sense sheet for an examination?

Ultimately, we are faced with the necessity for beginning a long-range program to educate a new type of professional. This professional will be a person with medical knowledge and skills who is also skilled in the use of computers, information, management, and learning systems. It is essential to develop completely new concepts of the role of the physician in a system wherein factual knowledge and the deductive reasoning process become more the burdensome chore of computers than of doctors. Without this step, the benefits of computerized medical education and medical management will not be realized.

The complexity of modern society has placed demands on medical care that make it imperative to redefine the role and *modus operandi* of physicians. Tomorrow's physician must practice in concert with specialist colleagues and instruments -- a challenge that demands the extension of a human mind through computers. To be able to handle this prosthetic device efficiently, doctors must learn to become involved in the development of medical systems early in their career.

Computers and the Curriculum: Summary of Open Discussion

The discussion that followed these two presentations revealed general agreement that computers are important for medicine and have a place in the medical school; however, the problems are how to get it there and, once it is there, where to put it.

The current movement in medical schools away from the teaching of pure science and toward a more clinical approach will make it difficult to introduce a subject which can be viewed as another scientific course of only indirect relevance and utility. Computer science will not be viewed less hostilely by the clinicians than by the scientists. Students demonstrate great impatience with anything that is not directly applicable to patient care.

On the other hand, it is certainly possible to teach a computer course in such a way that it appears pertinent and exciting, basing it on medical problems and making the students understand the importance of the computer in modern medical practice. Such a course might be considered a "computer appreciation" course -- intended to make the student appreciate the importance of the computer in medicine.

The problem is aggravated by growing diversity of students in background, interest, awareness and capability. A simple introductory course will be criticized by the students (and there are many of them), who arrive at medical school with considerable education and experience in computing. They will find this approach too unsophisticated.

There is very little chance of getting something new into the medical curriculum without getting something else out: there is no time for additional material. If computing is to go in, something else has to be given up. Mathematics in the medical curriculum could be reevaluated. If there is any mathematics at all, it is liable to be statistics and, beyond that, biomathematics. Most of the students abhor these subjects; the courses are drastically in need of rethinking and restructuring. This may be the ideal place to insert the computer-related course. The statistical techniques can be included with something that is more important and that will interest the students more.

In attempting to improve computer education in the medical schools, the basic problem may be the education of the faculty and the physicians in the community. As long as these groups are unaware of computers or indifferent to them, the average student will not be tempted to think otherwise. If the medical school is using computers and terminals routinely, the student will become comfortable in using them and will not be afraid of making use of them again in the future.

The Logic of Medicine

The basic problem in the application of computers in medicine and in medical education may have to do more with the nature and form of medical information than with computer science as such. The current logic of medicine is based on a philosophy of data acquisition and management that is 75 years old. Is it not possible that some of this logic will have to be redone in order to make use of the computer? Perhaps the way questions are asked of patients is not well-designed. With a better logic of medical data taking, it might even be possible for the questions to be asked without the involvement of the physician.

Evidence shows that physicians bias their questions, often inadvertently. In a test where different doctors asked a group of 60 patients 11 basic questions, they got an average of 2 to 3 different responses to the 11 questions from the same patient. There are important skills involved in asking questions so as to get answers that are not misleading. The patient's subjectivity (as well as the doctor's) is involved. At Ohio State, one of the basic courses for students deals with the sociology of interviewing. It is taught by sociologists, not MD's, and deals with the science of approaching the patient and of asking questions so as to get unbiassed answers.

The change necessary in this area of medical education can contribute to the introduction of computers in medicine. The achievement of such a change in the logic of medicine and in the way physicians think will encourage a coalescence of medicine and computer science.

Perhaps the need is for a graduate program to be offered for a limited number of people in medicine and computers. Such a program might develop people who have a knowledge of both fields sufficient to bridge the gap and develop new contributions to medicine. Developing such specialists takes special centers and special money, which is difficult enough. But such centers will not solve the problem of providing computer education generally among medical students. The computer is a fantastic tool that can multiply the powers of the physician enormously; yet medical schools are still graduating students who know nothing about it. In time, general knowledge and ability will come, but it seems to take too long. The electron microscope was introduced and gradually became an accepted part of the equipment of medicine and medical education. The medical profession cannot wait 25 years for the computer to receive this kind of acceptance.

The content of the course for the general student must not be excessively technical. Too many courses start and end with teaching programming, as though that were the total content of the subject. It should start at the more conceptual level of how people deal with information and manage data. It should focus on the logic of medicine.

Computer Aided Instruction

At Ohio State and at a few other institutions, there has been some experimental use of CAI programs in medical education. This is the use of the computer as a tool of instruction rather than as a subject of instruction or as a tool of medicine. Generally CAI is viewed as very expensive, too expensive in fact for many applications. But in some environments it has been successful. At one pharmacology school, for instance, case-studies and problem-solving vehicles have been developed on the computer. Students are very enthusiastic about them and they seem pedagogically effective. There is no reason to believe that CAI may not ultimately be as successful as some examples of audio-visual, audio-tutorial, and television instruction.

Conclusions

Computer science is important for the future development of medical practice and must be introduced into the medical schools. There are a number of ways in which this can be done, each appropriate in different contexts.

A critical need exists for some means of accelerating the pace at which links between medicine and computer science are being built. There is a need for specialized people who know both sides and who can develop the interfaces.

It is essential to move rapidly, but the question of cost was not even touched upon in this discussion. People who can help utilize computers in medicine are needed, but a good program will not be developed by ignoring the question of medical information and the 75-year-old logic which forms the basis of medical practice.

Special Topic 12: ADMINISTRATIVE COMPUTING

Chairman: WAYNE PATTERSON
Executive Vice President
University of Vermont

ANTHONY RALSTON
Chairman
Computer Science
Suny, Buffalo

MICHAEL ROBERTS
Director
Administrative Computing
Stanford University

Mr. Ralston began the meeting by presenting his views on three factors present at a large number of universities:

1. The general illiteracy among high university administrative officers about computing;
2. The shoddiness of many university business affairs operations;
3. The technical incompetence and narrow outlook in many computer professionals.

Ralston believes it hardly surprising that so few senior university administrators are knwoledgeable about computing when most of them began their careers before the computer had reached its present prominence. The mediocre quality of business personnel is equally understandable:

at its highest levels, academic administration is a profession without the power or salary of business or industrial management; it has less prestige than the faculty; and people have too often been at their jobs too long. As for computer professionals, computing technology has advanced faster than computer education. Until computer education catches up, perhaps in the next decade, many computer installations will be staffed by people with less competence than their jobs require.

If the data processing function is running smoothly and efficiently, Ralston sees no reason to change it. However, when a change is necessary, a strong case can be made for a joint academic-administrative center for computing. Such a center should not report through either the academic or administrative sides of the university. It should report directly to the president's office or, along with libraries and communications, to a vice president for academic resources.

But the political and administrative realities will sometimes require that the computing facilities report to an already existing office. When this is the case, Ralston believes the officer should represent the academic rather than the administrative side. In the educational environment, administrative data processing must take a back seat to academic computing. This, together with the likelihood that an administrative vice president will not understand academic computing, militates strongly against administrative control.

As an example, Ralston cites what he considers to be a decline in computing at SUNY, where control of computing passed from the academic side to the office of the Vice Chancellor for Finance and Management. Ralston views the result as poor support for academic computing, increased control of the campuses by central office, and some bad decisions on future plans.

Related to the general organizational problem is the question of the centralization of data processing in multicampus institutions. For a university or group of institutions with relative homogeneity in the administrative processes, the arguments for standardization and centralization are compelling.

SUNY has plans to standardize administrative data processing at 11 four-year colleges by installing identical hardware and software at each of the colleges. Ralston made several comments on this plan. First, the motivation is administrative standardization; yet the computers will also be used for academic purposes. This reflects a misordering of priorities. Second, the installation of standardized hardware and software will not assure standardized procedures. Without a carrot and a stick, most campuses will continue to do things their own way. The carrot should be consultation and joint study with the local campuses on the procedures to be standardized. The stick would be the centralization of hardware, which would require the campuses to make use of the standard system. In fact, if the procedures and software are to be standardized, then economy of scale clearly favors a centralized hardware system.

Before administrators can make a start toward creating good management information systems, they need to know what is possible and what they should ask for. They must learn what constitutes appropriate management data at various levels in the organization. These suggestions can be given to the manager responsible for the design of an information system:

1. Know what is possible and ask for it; do not accept "that can't be done" as an answer
2. Insist on appropriately summarized or exception data.
3. Make sure that data processing planning is integrated among departments and is long-term, but also make sure it is integrated serially.
4. Distinguish between useful systems and gimmicks.
5. When you don't get what you want, be sure where

the fault lies.

6. Don't let yourself get sold too easily on wonderful new systems and the kinds of changes that lead to instability.

Further, it is important to distinguish between operating information (current budget reports, endowment reports, etc.), tactical information (budget projections, admissions projections for next year, research grant trends), and strategic information (information for long-term planning).

How can higher management tell whether they are getting a good return on investment, whether they have a good data processing staff and system? First, by having someone on the staff with enough technical competence in computing to be able to make this judgment. Second, by judging relative as well as absolute performance: a bad operation cannot be changed over night. Third, by evaluating whether they are getting the information (operational, tactical, and strategic) needed to manage the university. Fourth, by knowing the difference between real computer systems and computerized manual or tab systems.

Michael Roberts

Michael Roberts stated that, within a few years, a major cost of any administrative operation in the university will be the computer cost; support in many cases will equal 50% of total expenses. For an item of this importance, administrators are not paying enough attention to computing costs. Influenced by their lack of specialized knowledge and the shortage of time, they have left too many of the problems to the technical people to solve and, in doing so, have abandoned their management function. They sometimes believe that computing is too complicated for them to understand; in fact, however, if their computer people cannot explain things to them in terms they can understand, they need new computer people.

One of the responsibilities of computer people is to educate the decision-makers. They are at fault if they do not perform this function. But the fault is not all on their side; the analyst or computer center director very often does not know what it is that the administrator needs to know; he cannot see the world from the administrator's perspective without some help.

If middle management is to use computers and systems effectively, they must develop new approaches and foster close cooperation with the computer people. One factor that has led to ineffective use of computers is the inadequate involvement of users in design, installation, implementation, and operation of the systems they use. This leads to an air of hostility that is inimical to the effective use of systems. If users view the system as something that is being imposed on them, and not as something to help them, there is no way in which it can ever work for them effectively.

System design should begin with a review of the global constraints that will affect the system: necessary data and files, size of files, transaction frequencies, report formats, and so on. Given these considerations, it is then possible to design hardware requirements and consider utilization figures. If operation is going to be less than 60% (400-500 hours per month), some other alternative should probably be considered. Underutilized hardware is never cost-effective; a very small hardware configuration is difficult to staff. Unless the total operation will cost 1/4 to 1/2 million, a better solution may be found in a service bureau, a cooperative activity, or a regional center.

By and large, there has been totally inadequate cost/benefit analysis in computer applications. To some extent, this is due to the fact that the real need for computing relates to the style of management as much as to any purely economic arguments. If a management team becomes accustomed to a level and style of computing which gives them certain kinds of information, they become very reluctant to give it up.

The absence of adequate and appropriate billing and accounting schemes for administrative computing support has been responsible for difficulties in administrative practice. The computing center is responsible to provide services to all of the functions that ask for it. However, the manager in charge of that function cannot do his job and evaluate the effectiveness of his methods without knowing what he is really paying for computer services. When the cost of the computer comes out of his budget, the user becomes more involved with his relations with the computing center and more aware of what the computer support is worth, in terms of his satisfaction with the results.

Centralization

Much of the subsequent discussion focused on the centralization of campus computing resources. Some kinds of use disrupt service and some do not. Computer science instruction and research make very special demands, which may be incompatible with requirements for stable service. Even at institutions with major, centralized facilities such as Case-Western Reserve and Dartmouth, special computers are available for computer science use. Beyond this distinction, there seems to be little important difference between the typical academic user and the typical administrative user. Both have problems of deadlines, want fast turnaround, need service designed for economical debugging, and so on. The failure to make the distinction about disruptive use is responsible for some of the difficulty in centralization.

When a single campus computer center is established, the merger of the programming and analysis staffs for academic and administrative systems may be much more difficult than the merger of hardware and policy. The systems programmers of the academic center are liable to be bright, brash young people; the administrative applications programmers are oriented more to the applications than to the computer: they may know little about computers other than a single procedure-oriented language. But although their merger into a single group is difficult, it may have salutary effects. The systems programmers learn something about the constraints under which users operate and how their requirements affect the design of systems. The applications programmers may learn how out of touch they are with modern methods and machines and may attempt to learn more.

When programmers work for the center, they may be too distant from their customers; however, when they work for the customers, they are too distant from one another. The technology and the need for information founded on a wide basis of data are wiping out the boundaries between administrative areas; there must be more common data and files among the users. If such broad data bases are to be designed, communication among the applications programmers is an absolute need.

The problem of creating a single, multi-function campus computer center may be changed before it is solved. There appear now to be two additional alternatives: regional, multi-institutional computing, and mini-computers. With regional centers, institutions have been able to move both their academic and their administrative computing to a higher level of centralization. Mini-computers will very soon eliminate the economic argument for centralization; however, as far as administrative use is concerned, the mini is of questionable utility. Retreating to your own little machine and ignoring the need for broader data bases will not help solve the problems of managing the university.

One reason a number of administrators are unwilling to relinquish control of their data to a single centralized agency is the problem of security. Security, in a computer system as elsewhere, is relative and never absolute. Administrators complain that the computer-based systems are not totally foolproof; yet, in many cases, it would require far less time, effort, and ingenuity to break into the payroll office than the break into the computer system. Information can be made so difficult to access that no reasonable person will find it worthwhile.

Academic users, as well as administrators, fear a loss of service in a centralized system frequently because of past disasters. At most institutions policy dictates the priority of academic over administrative service, but academic users are suspicious; they will not believe they are getting service which as as good as that which the administrators receive. Administrators can always blow the whistle by saying, "What is more important than the payroll?" Such an argument is basically emotional and has little factual basis. Conflicts like this just should not occur. With modern systems of hardware and software, there should be no reason except in the smallest installations to have to decide between payroll and something else. It should be possible to do both. The argument usually presents a hypothetical case; there are few crises and relatively few real conflicts at most universities. At universities that have never tried to cooperate, it is a good argument; many administrators and faculty are unaware of the progress made in the past few years in developing systems of efficient multi-programming. They are worried about problems they have seen in the past.

Special Topic 13: ADMINISTRATIVE SYSTEMS

Chairman: HARRY A. SPERBER
Director
University Management
Information Systems
Pennsylvania State University

JAMES L. MORGAN
Director, Management
Information Systems
State University System
Florida

Reports were given by the panelists on the processes involved in the development of administrative systems in Pennsylvania and Florida. The discussion focused mainly on these systems.

Pennsylvania State University

Penn State is a big institution. There are 25,000 students at the main campus; twenty-two other locations, including a medical center, enroll another 15,000 students. The main campus has separate computer centers for administrative and academic computing. The academic center has a 360/50 and a 360/67, with terminals (largely 2780's) at most of the campuses. Several of the campuses have 360/20's for high-speed RJE.

The administrative center has two model 50's and one 20. (The two 50's may be replaced by a single 370/155.) The workload includes a considerable amount of work for agriculture as well as the traditional student records and statistics, financial accounting, and so on. The current breakdown on the load is 40% financial, 40% student records, 15% agriculture, and some miscellany. The center operates as a service bureau, in which the users pay for everything they use: machine time, programming, and systems.

Service is charged to the users on a month-by-month basis.

This creates a peculiar environment and some special problems. A center that is driven by the need for income tends to include too much hardware -- because it is anticipating everything that might happen. A second danger is that the center, in order to improve its financial situation, encourages computer use, regardless of its worth to the interest of the University as a whole. If the goal is to create a financially viable service bureau and not to provide the best and most economical service to the University, the computer center suboptimizes.

For example, a microfilm system was recently introduced in the Pennsylvania State system. This improvement had the impact of reducing cost to the user and at the same time reducing income to the Data Processing Center. There should be some way to redirect some of the savings to the computer center, which in this example bears the costs; otherwise, the interests of data processing may not be the interests of the university as a whole.

Like many other institutions, Penn State recognized a need for a new approach in administrative systems which would include the integration of data across traditional lines and the creation of a management information system that would have access to a total data base of university operations. Two years ago, a committee was established to consider this problem. As a result of their recommendations, a University Management Information System Group was established, which pulled together all of the administrative data processing, systems planning, programming, and systems design.

In the earlier organization, the Data Processing Center reported to the Controller, which created the usual difficulties of a computer center under the control of one of the users. In order to correct this situation and to recognize the management information system as a university-wide function, the new organizational unit reports to the president via the vice-president for academic affairs.

Florida

Florida is in the process of revising its budgeting and planning practices to utilize program planning and budgeting techniques. Unfortunately, none of their computer-based systems had been built with PPBS in mind and needed extensive revision. Further, the systems were fragmented and lacking any kind of compatibility with one another. They were functionally useful in the particular areas in which they were developed, but they couldn't be used for any broader purposes. Even the admissions system and the student records could not be tied together.

Because of these two problems, it was decided that the entire system would have to be replaced with a new one, written from the ground up with data base management and program budgeting in mind.

The method used required extensive user participation. Representatives of nine institutions were asked to get together and standardize their systems: not simply to adopt common coding, but to create a single, standard system. The first system begun was student records. An interinstitutional task force, consisting of four registrars and three data processing people, was created to design the system. The proposed design was submitted to the other registrars, and coordinated with planning and budgeting, academic personnel, and institutional studies. When agreement was reached, the programs were developed for the new system.

The admissions module of this system is now running in three institutions. The development was not achieved without some difficulties. The major one was the considerable underestimation of the problem of documentation in inter-institutional systems, in particular, documentation for the purposes of the ultimate users on the nine campuses. It is extremely difficult to write instructions for the clerks in the admissions offices, who will have to rely on the documents and will not be able to ask the people who developed the system to fill in a detail they do not understand.

The general development scheme is designed to install a system in a single pilot school first and then gradually spread it through the state schools. However, in the case of the admissions system, three schools volunteered and are all simultaneous pilot users. There are plans for annual in-depth auditing of systems following installation to be sure that they continue to be responsive to the needs of the users. When deficiencies are found, the process will begin again with system design, development, pilot installation, and so on.

Other systems are under development, including financial, personnel, and facilities packages. After the new financial system was completely designed, a new controller and a totally new financial team were hired by Florida State. They examined the planned system and found it totally satisfactory; this was viewed as a major success by the development team.

Too many good systems are endangered by having people who do not know how to use them. This problem has been approached at Florida State by means of an educational program. Courses are given which begin with a week of computer concepts (the IBM customer executive classes) and continue with detailed instruction on the particular system in question. So far, three such sessions have been held. They have not solved the problem totally; greater educational services are required.

One plan proposed for organization of the system maintenance function calls for decentralization with specialization. Rather than using a single centralized staff which may lose contact with the users, or decentralization in which every university has people with competence in every area, each major campus may be assigned functional responsibility to a single system area.

Instituting such a system requires a certain amount of authoritarian leadership. At Florida, a considerable effort was made to place the emphasis on "leadership" rather than "authoritarian". If systems are forced on people who do not want them, the systems will fail. The ultimate users must be involved in the design of the system and feel that they have control.

At some institutions a lack of user involvement has created problems. At Oregon State University, for instance, a plan similar to Florida's is being instituted. However, a central group is developing the statewide system. Oregon State University has been using an on-line administrative information system. Administrators have grown accustomed to sitting down at a CRT and getting immediate response. They are understandably skeptical of the virtues of the proposed batch system with its periodic reports. A new system must be at least as good as the systems it replaces. If there are some institutions that are a step ahead of the others, the central administration must be prepared to match the service to which they are accustomed or face problems.

The Florida method escaped this problem by having people from the institutions themselves act as the design team. In this way, the systems sometimes include features that the central staff would have preferred to see changed; but the involvement of the ultimate user and his cooperation are more important functions than the details of the system design.

Will the Florida system ultimately combine the administrative and academic computing centers? There is less and less argument for separation of computer functions. However, it will take time and planning. All nine institutions occasionally need computer time for academic purposes; however, there are only two that are major research centers. Should academic use be serviced at all four of the present centers or only at one or two? These questions will be answered after careful study of the universities and their needs. One can only solve one problem at a time.

III. GOVERNMENT POLICIES AND PLANS

PANEL DISCUSSION

Chairman: MARTIN GREENBERGER
The Johns Hopkins University

WILLIAM NISKANEN
Office of Management & Budget

RAYMOND BISPLINGHOFF
National Science Foundation

JOHN MAYS
Office of Science & Technology

GREENBERGER: When someone shouts "fire!" in a darkened theater just as we are wondering whether that is smoke we smell, our immediate reaction is to look for the nearest exit and get ourselves to it with the greatest dispatch. In times of adversity, our first inclination is to look for the fast solution. We resist taking the time to ask questions aimed at illumination or deepening our understanding of the problems affecting us, and we are prone to forget about others similarly afflicted. If given in to, these tendencies are almost always self-defeating.

The problems that colleges and universities currently face in computing are common problems, even though an individual institution may give them its own special character. We may wonder if they are even unique to computing.

We know that the university has many problems today. Are the problems of computing really significantly different from those of the library, the bookstore, or the other operations of the university in its present unsettled state? People in computing may believe they are, but how about the college or university president? Does he? And how about the agencies of the federal government which may be called upon to help? Do they?

We may not know for sure, but we are about to learn something of the views (and questions) of a few members of some important government agencies. The panelists in this session will not be speaking as official representatives of their agencies, but as individuals with a broad perspective stemming from their familiarity and concern with a wide gamut of national problems in science, technology, and education. They are not specialists in the computer field, but neither are they unacquainted with it. Almost all of them have had direct association with computers in positions they held before assuming their present government posts.

It would be unreasonable to expect any of the panelists to have ready-made solutions to propose to the problems we are discussing. Nor are they in a position to suggest the possible ways that government might be able to alleviate these problems in the future.

But what I believe the panelists can do -- and very authoritatively -- is to inform us of the current thinking and policies in Washington as they relate to science, technology, and education in general, and also of their own agencies activities in the computing area. They will most assuredly want to raise questions with us about why the federal government should be specifically interested in the problems of computing, and the audience in turn will be able to raise questions with them reflecting its concerns and points of view.

The first panelist, William Niskanen, serves at the Office of Management and Budget as Assistant Director for Evaluation. He assumed that position in October 1970. Before that he was with the Institute for Defense Analysis as Director of the Program Analysis Division, with the Office of Systems Analysis in the Department of Defense, and a staff economist with the Rand Corporation. Although it may not be too well known in Washington, Mr. Niskanen has a Ph.D. degree from the University of Chicago.

NISKANEN: My remarks should be interpreted in the light of the facts that:

1. My views do not necessarily reflect the positions of either the Administration or the Office of Management and Budget.
2. They are not based on detailed, current knowledge of the policies, programs, and institutions relevant to the "computing problem."

Because of this lack of both official status and detailed knowledge, my views will be expressed with rather more assertiveness than might otherwise be the case.

My interest in participating on this panel was stimulated by the chairman's desire to have a "panel discussion on the Government's relationship to the present situation and the measures that it might take now or in the future to foster a healthy development of computing in the country." Now, bureaucrats are as much interested in "healthy developments" as anyone else, but our interests are not limited to computers. After a preliminary reconnaissance, I failed to find any particular government policy either to promote, restrict, or otherwise affect the use of computers in the country or specifically in higher education. Moreover, for the life of me, I cannot divine any reason why the government should have such a policy for computing, anymore than for professional staff, office space, janitorial services, or any of the other inputs to the education and research processes.

Government has an important role in contributing to the financing of education and to those types of research that cannot be adequately supported by the private sector. And the total amount of government funding of these activities, contrary to popular impressions, is still increasing at a faster rate than the proportionate growth of GNP. Our interests as managers of public expenditures, however, are in the output of educational and research activities, not in the specific combination of inputs used to produce these services. As a consequence, at the same time that the total government financing of these services is increasing, the funding available for some specific inputs is being reduced. We want to pull education and research through the relevant processes, rather than to try to push certain inputs to these processes. In any case, for any process for which there is a considerable opportunity for substitution among the several inputs, the effects of trying to push inputs are much like trying to push a string.

The only government policy relevant to this discussion for which OMB is directly responsible is spelled out in Circular A-21, which bears on the "principles for determing costs applicable to research and development and educational services under grants and contracts with educational institutions." In this lengthy and frequently revised Circular, the only two principles which specifically bear on computers are the following:

1. The schedule of rates on computer services should be designed for expected full-cost recovery over a long period -- not necessarily just a year -- agreed in advance by the federal government and the

institution.

2. The schedule of rates should be non-discriminatory among users of the same type of computer services. These principles are intended to permit each institution to set rates which are independent of costs in any specific year or period and may differ by type of service. What more can be fairly asked of the government in this case?

Until recently, I was a research manager of a division of a non-profit institution that was a major user of computer services. If my experience is at all representative, the "computer problem" appears to be primarily a consequence of a combination of overinvestment and undermanagement. Decisions on size and type of computer are too often based on technical criteria (frequently because someone else picked up the bill for the computer's initial installation), and decisions on its use are too often based on a perverse system of average cost pricing that makes the computer cheap when it is very busy and expensive when no one is using it.

The overinvestment problem can be corrected only by balancing technical criteria against economic criteria at the time of acquistion, with specific attention to the few idiosyncratic demands which have often driven the selection and characteristics. The malutilization problem, I believe, can only be resolved by a "demand-rationing" schedule of rates. I am intrigued with a three-rate schedule that has been used successfully in several institutions: The highest rate applies to immediate turnaround and is used primarily for medium length problems. The lowest rate applies to turnaround by the following morning and is used primarily for long problems. It is important to recognize that the rates are set on the basis of the turnaround *requested* at the time the job is submitted and not on the actual completion. All of these rates (as long as they are above the nomnal variable costs of operations, which are for the most part quite small) can be periodically changed as a function of *expected* demand over some future period (such as one to three months.) Other specific rates should be set for use of memory files and peripheral equipment. In any short period, depending on demand conditions, the total charges to users may be more or less than full costs, and this is fully consistent with Circular A-21. If the original investment decision was correct, however, there should be no problem of meeting the full costs over an extended period. And, of course, the government would not be likely to get terribly concerned if it were undercharged

After a period of rapid growth, and during a period of continued technological change, the computing business finds itself in a "sorting-out" period. Many of the problems have arisen as a consequence of managing the computer as a "free good." As both government and university budget officers are painfully aware, however, only a few of "the best things in life are free," and these do not include computers. I am confident that the nation and the universities will continue to expand their use of computers, and, after the "sorting out" period, in a more efficient manner. This conference can make an important contribution to that end.

GREENBERGER: The next panelist is Raymond L. Bisplinghoff, who serves as Deputy Director of the National Science Foundation. Dr. Bisplinghoff came to NSF after a distinguished career at MIT, where he was professor and chairman of the department of aeronautics and astronautics and most recently Dean of the College of Engineering.

BISPLINGHOFF: Dr. Greenberger earlier gave a brief history of some of NSF's activities in supporting college and university computing centers. I would like now to identify several different phases of this history from the viewpoint of NSF's objectives, and then conclude with a discussion of the present situation and what we see in the foreseeable future.

Four periods can be identified in the history of NSF's support of college and university computing. The name of each period as I discuss it will highlight its activities. And you will be able to see, I think, that the trend is obviously one of increasing complexity of research use.

The period Early Years is characterized by the role of NSF as a catalyst in an area of emerging national importance. I think the NSF program was particularly successful in these years in leading many hesitant academic administrations into support of the new computer culture. In the Early Years, as so many of you know, a scientist was very often his own problem analyst, programmer, key puncher and computer operator. I remember so well my own struggle to program the Whirlwind computer in the late forties and early fifties.

The NSF grants in the period of the Early Years were mainly for the acquisition of computing equipment. The first grants were in FY 1956. There were five -- to Cal Tech, MIT, Oregon State, Washington, and Wisconsin.

The advent of transistorized computers in the early 1960's with improved reliability, higher-level programming languages, and greater capacity brought about a rapid expansion of scientific computing in the period that might be called Rise of Campus Centers. Centers for campus computing became distinct organizational units -- complexes of equipment and staff centrally located in the administrative make-up of institutions. Also, during this period initial research efforts in time sharing were underway, developments which were to bear fruit in later years.

NSF grants for central computing facilities were made to many institutions -- Stanford, Illinois, Wisconsin, Cornell and Columbia, to mention just a few.

In time-sharing research, projects at MIT in 1961 led to the first successful time-sharing demonstration involving three flexo-writers. Project MAC with ARPA support followed shortly, and the work at Dartmouth is also well known.

One other noteworthy project with a lifetime that overlaps this period was that of the Western Data Processing Center located on the UCLA campus. With major underwriting from IBM and some from the Foundation, computing services were provided essentially without cost to over 100 schools during the years 1956 to 1967.

The period called Expansion, Refinement and Cooperation marks the establishment of the NSF Office of Computing

Activities. This period is characterized by research and development efforts in computing centers. Many projects had a highly experimental, exploratory, or developmental nature.

This period could also be called the "Age of the Institutional Computing Services Program." This ICS program, as it was called, dealt with the problem of providing advanced computational services in support of scientific research. In this program the Foundation played a vital role through its staff, consultants, and advisory panels, since many of the projects had extensive technical, management, financial, and planning aspects which had to be analyzed in the review process. The program required institutions to develop a sound plan, demonstrate management competence, and justify the academic need for a proposed level of computer development.

It is easy to focus on hardware in describing the ICS program, since a computer or major components of a computer formed an integral part of most development proposals. Computer hardware is expensive, visible, and the subject of much "shop talk" among users. Yet many of the development projects carried out under the ICS program were in the forefront of new computer applications in research.

A significant new period of computer applications in research is emerging in Fiscal Year 1971, although a few grants indicative of this new period were made in earlier years. This period which might be called Research Computational Technology, emphasizes the exploitation of advances in computer technology which have great signifigance in research. The potential usefulness of computers in research has increased markedly with advances in technology which make possible a high degree of interaction between the researcher and the computer, enable computers to be accessed by a variety of remotely located terminals, and permit computers to be used on-line in complex experimental research activities. Some scientists in quantum chemistry, for instance, believe that the time is coming when contributions to that discipline may come as readily through access to properly designed computational techniques and facilities as through access to a laboratory. Such an approach requires the most imaginative talents of both computer scientists and quantum chemists. I myself have seen in the last few years how the use of computers has eliminated the need to make large numbers of wind tunnel tests of supersonic airplanes.

As to the future, given the visible developments in computer and communications technologies and the needs of scientists, we are examining the benefits and costs of various specialized regional and national computing centers. As examples, I can enumerate:

(1) a general-purpose "super computer" for number crunching;

(2) special-purpose major computer centers for computer "experimentation" (for example, the one for quantum chemistry I just cited);

(3) special-purpose computer centers designed especially for given functional applications (for example, pattern recognition, statistical computations, data-bank applications);

(4) special discipline-oriented centers primarily for software research to increase research capability, rather than to provide a service component for substantive research in the disciplines; (The first major national center of this kind is now being established under a 5-year continuing award to the National Bureau of Economic Research for research in computational technology in economics and management science.)

(5) a center for the purpose of analyzing, testing, certifying, and distributing selected classes of computational hardware.

I would like to conclude by relating NSF's support of computing to one of the numbers that Dr. Greenberger mentioned earlier. In its 1972 budget, the Foundation is requesting from the Congress some $17.5 million for the direct support of computing activities. These various activities fall under the Foundation categories of computer science and associated engineering, computer innovation in education, and computer applications in research. We estimate that perhaps another $10 million goes into the support of university computers indirectly through our research programs. This means that the total NSF support to university computing for operating funds in 1972 may be on the order of 25 to 30 million, which is under 10 percent of the total mentioned earlier by Dr. Greenberger. This gives some indication of NSF's leverage in this total activity.

My guess is that the NSF policy in the foreseeable future will be primarily one of funding innovations in computer science and engineering, education, research, and computer activities that relate to its own research program, rather than one of providing sustaining monies for computer centers.

GREENBERGER: Our final panelist is Dr. John Mays of the Office of Science and Technology. I shall let him tell you in his own words about the function of OST and his responsibilities in that organization.

MAYS: The Office of Science and Technology is part of the Executive Office of the President, as is the Office of Management and Budget, but it does not control how money in the government is spent, as does OMB. Nor is it a granting agency, as is NSF. I cannot therefore tell you about our plans for spending money in computers, because we do not have any such money.

The director of OST is Edward David, your erstwhile colleague, who is also science advisor to the President and chairman of the President's Science Advisory Committee. OST *is* concerned about the details of what goes on in computing. It is interested in computers as elements of science and technology, in information systems, in computer science and engineering, and in computers in education -- not only in higher education, but also in elementary and secondary education.

The area of my primary interest in OST is research and development in educational innovations. I think we are returning to the concept of using the computer and other forms of technology in education to help control the cost of education, possibly for the support of science, and I cannot make any predictions on the future of that. It seems to me there is rather general agreement that there is an overcapacity of computers in universities today. I think Martin Greenberger is right, that a new phase in the development of computing has come and new equilibria are going to have to be established. I think one of the guiding principles in this new phase is that computing decisions will have to come more directly into the regular decision-making procedures by which educational and scientific money is allocated. The idea of a separate computer facility which somehow stands apart from its users is a thing of the past.

I think one of the most useful things that could come out of this conference and future deliberations on these problems is to arrive at a consensus on whether there are some particular ways, other than the ways Dr. Bisplinghoff has already suggested, in which the federal government might help in the transition to phase four in the development of computing.

GREENBERGER: We have time for three questions from the audience, one for each panelist. The first question is from David Freeman, director of the computer center at the University of Pennsylvania, who asks Mr. Niskanen to what extent the Office of Management and Budget scrutinizes the budget of individual offices of the National Science Foundation and recommends revisions to them. Mr. Freeman notes that the Institutional Computing Services program of the NSF was recently abolished, to the dismay of academic computer center directors and possibly some NSF officers. What role, if any, did OMB have in its abolition?

NISKANEN: I cannot answer the question authoritatively because the detailed review of the NSF budget is not made by a program examiner in my division of OMB. OMB's general relationship to NSF and other federal agencies, though, is primarily to provide general guidance. We have high confidence in the leadership of NSF. In the circumstance in which

which I hardly need tell you is growing very rapidly these days -- perhaps 5 percent more rapidly than the general price index. Under these conditions, education will double in price with respect to other goods within fourteen years. We see technology, including computers, as being able to make a contribution, not by adding costs to the budgets of institutions but by replacing and reducing other expenses.

With respect to the stress that many institutions are feeling now in computing, this is a matter of concern to us. We are anxious to see that federal policies facilitate the long-run, positive benefits that continuing advances in computer and communications technology make possible; and not add to the difficulties confronting the universities unnecessarily.

We have gotten the impression in talking to a number of people around the country with an interest in computers, that they believe that certain government policies may indeed be contributing to the difficulties. OMB Circular A-21 is one; antitrust policy and its effect on educational discounts is another; the termination of NSF support of computing facilities is a third; and a fourth, the fact that government support of science and technology that could potentially make use of computing facilities has not gone up as rapidly as many universities expected it to when acquiring new equipment.

On this last point, things really are not as bad as they are sometimes painted. The President's budget this year provided for an estimated 14.7 percent rise from $1.653 to $1.896 billion for research and development in colleges and universities. Of course, this is the President's request and it still has to be acted upon by Congress. Also, we are well aware that the increase may not necessarily find its proportionate way into computers. We must face the fact that optimizing the use of computers is not one of the factors taken into account in the government program on support of research.

I am not citing an official position, but if I may hazard a personal opinion on the current thinking, I do not see any great likelihood of these policies changing, except

NSF's total budgets are going up, we have conveyed some general guidance to it (and probably some specific guidance which I may not be aware of), and then we count on Dr. Bisplinghoff and Dr. McElroy to organize and manage their organization using those ground rules.

One of the more interesting phenomena around Washington is that when an office either gets too busy to do its own task well or really does not have anything else to do, it tries to manage some other organization. The State Department, because it does not have much to do, tries to manage the world. I hope that the Office of Management and Budget has just about the right amount to do so that it is not guilty of trying to manage other organizations.

GREENBERGER: With respect to the Institutional Computing Services program, my impression is that its abolition was not a government decision specific to computing but rather fell out of the general decision to cut down on institutional grants of all kinds.

NISKANEN: That is correct. There is a general policy relating to NSF and other agencies to reduce institutional support of specific inputs to research and educational processes, to redirect that kind of past funding to either student support or direct support of research activities, and then to leave to the institutions which organize these activities the choice of how to combine the inputs to reach their desired objectives.

GREENBERGER: The next question, directed to Dr. Bisplinghoff, is from Professor Richard Hughes at the University of Wisconsin. Professor Hughes is chairman of a long-range guidance committee at Wisconsin charged with planning for the university's future computing system. He asks Dr. Bisplinghoff about the factors that have made NSF feel that special-purpose centers are better than general-purpose ones. Or is this a misinterpretation of the new NSF policy?

BISPLINGHOFF: I would not call this a policy, but rather an examination of the benefits and costs of various specialized regional and national centers. Would we achieve a higher cost effectiveness, for example, if we had a special-purpose major computer center for quantum chemistry, or one for pattern recognition, or one for statistical computation? What we are doing is looking at the desirability of having such centers similar to the centers we have for large telescopes, accelerators, and reactors. But this is mainly an examiniation and a probing, not an established policy.

GREENBERGER: The final question for John Mays was submitted by Ivan Frick, president of Finley College. He asks why the federal government has chosen to provide grants primarily to large research-oriented universities so that the undergraduate and the undergraduate educational program end up getting the short end of the stick in the government support of computing.

MAYS: The idea that somehow computing can be an "add-on" to the other requirements of undergraduate education is one that I think we are moving away from. What we are moving toward is to ask institutions to look in some detail at what it is they are trying to do and to try to relate the inputs to the educational process to those objectives. It is my own opinion that in this analysis various kinds of computing might turn out to be considerably more valuable than other activities currently in effect, and will replace those activities ultimately.

The President has proposed two institutions now being considered by Congress that will address themselves to these questions. One of them is the so-called National Institute of Education. It would concern itself with research and development projects covering the whole range of education. NSF, of course, also is able to support and does support experimentation in this area. The second proposed institution is a National Foundation on Higher Education. It is intended not so much to carry out experimentation of the sort the National Institute of Education might do, but rather to help institutions implement and adopt educational innovations -- not by continuing institutional support, but as part of a planned program.

GREENBERGER: MIT and Carnegie-Mellon are two universities that have done some worrying about the problem of undergraduate education. I wonder if Dr. Schatz and Dr. Licklider would care to address themselves to this final question before we adjourn.

SCHATZ: The problem of undergraduate education has for some time been a troublesome one at our university. Many of our undergraduates, even though they exist on a campus with a great deal of computing power, do not feel as though they get enough computer time or help. But we have recently introduced some efficiencies in our computing center which have resulted in a significant improvement in the service to them.

LICKLIDER: I believe that the role of computers in undergraduate education is changing very rapidly. Computers did not play much of a role in undergraduate education until much too recently. A couple of years ago the provost at MIT allocated some money (now $120 thousand a year) to the undergraduate use of computers in education and asked a group of undergraduates to figure out how to spend it wisely. These students have done an absolutely fantastic job. They have convinced almost everybody. We now have 700 undergraduates registered as standard computer users. The undergraduates are also involved in research activity, not just at MIT, but all over the Boston area. I think that one of the best ways to put money into undergraduate education is to put it into research, and then let people find out that undergraduates are very good at contributing to the research.

Incidentally, it is unthinkable to me that the computer could be viewed by any office in Washington as just another "input", but this reflects the fact that it is used this way by too many people in universities. Until our universities themselves see it as one of the few great new forces at our command, and until we make adjustments in our universities accordingly, we cannot expect the government to understand what computing is really able to accomplish.

EDUCOM SPRING CONFERENCE

April 29, 1971

PHILADELPHIA, PENNSYLVANIA

LIST OF ATTENDANTS

William R. Agee
The American University

Leonard Alberts
Temple University

Bruce Alcorn
Southern Regional Education Brd.

John E. Alman
Boston University

Ernest Anastasio
Educational Testing Service

Dr. William F. Atchison
University of Maryland

Larry Aungst
Franklin & Marshall College

John E. Austin
Harvard University

Dr. Elizabeth A. Alger
College of Medicine & Dentistry
of New Jersey

Frank J. Bachich
Hahnemann Medical College

Dr. Albert A. Barber
University of California, L.A.

Samuel J. Barr, Jr.
Queens College of the City Univ.

Dr. Robert C. F. Bartels
University of Michigan

Dr. A. F. Bartholomay
Medical College of Ohio

Phillip Bartow
University of Pennsylvania

Robert Becker
Temple University

Joseph Becker, President
Becker and Hayes, Inc.

Stoughton Bell
University of New Mexico

Gary L. Bemiller
State of Illinois Bd. of H.E.

Dale Bent
University of Alberta

David J. Berg
University of Minnesota

Daniel Bernard
University of Pennsylvania

Daniel Bernitt
Penn State University

Stanley Bielak
Catonsville Community College

Dr. Raymond L. Bisplinghoff
National Science Foundation

Joseph G. Blair
Eastern Baptist College

Frank G. Blum
New York University

George F. Bock
Northampton Community College

Lorraine Borman
Northwestern University

L. Ward Bromall
Glassboro State College

Curtis Bryan
Delaware State College

Roland F. Bryan
University of California, S.B.

Dr. Oliver H. Buchanan
Pratt Institute

Dr. Russell Burris
University of Minnesota

W. Richard Burrows
University of New Hampshire

John Caffrey, President
Educational Systems Research Group

Peter J. Caffrey
New York City Community College

Edward J. Callaghan
Newark State College

Daniel L. Callahan, F.S.C.
LaSalle College

Henry Chauncey, President
EDUCOM

John W. Carr, III
University of Pennsylvania

Dr. Louis Chenette
Findlay College

Emile C. Chi
CUNY - Staten Island Comm. Coll.

Ralph Christensen, M.D.
Lister Hill Center for Biomedical
Communications

Dean E. Clarke
Worcester Polytechnic Institute

Kenneth Codlin
Yale University

Stephen D. Crocker
University of California

D.S. Crocket
Lafayette College

John A. Curtis
Analog/Hybrid Computing Ed. Soc.

Peter J. Czajkowski
University of Illinois

Robert M. Davies, Provost
Ithaca College

Ruth Davis, Director
National Bureau of Standards

Richard V. DeGrasse
University of Vermont

Dean G.L. d'Ombrain
McGill University

Thomas J. Donahue
University of Pennsylvania

Arthur Dorfman
The City University of New York

James Dougherty
LaSalle College

Richard Dowell
Digital Equipment Corp.

Gerald J. Duffy
Northern Illinois University

Howard C. Dunn
Mercer County Community College

William B. Durant, Jr.
Dartmouth College

Charles S. Duris
Drexel University

Philip A. Dylhoff
University of Iowa

Andrew Egeressy
IBM Corporation

George W. Elder
City University of New York

John Eldred
University of Pennsylvania

R. G. Ellis
University of Pittsburgh

Stanley Etersque
Concord College

Nelson Famadas
University of Pennsylvania

Dr. James Farmer
California State Colleges

Dr. Andrew G. Favret
Catholic University

Mac Felder
North Carolina Bd. of Higher Ed.

Dr. Julian Feldman
University of California

Charles M. Fogel
State University of New York

John J. Foote
University of Pennsylvania

Dr. Sidney Forman
Columbia University

Donald S. Fraley
St. Lawrence University

Rex Franciotti
SUNY - Stony Brook

Mrs. Marian Freeland
CUNY - Queens College

Dr. David Freeman
University of Pennsylvania

Dr. Ivan Frick
Findlay College

Robin P. Frita
Digital Equipment Corp.

Eugene Fucci
Dartmouth College

C. William Gabrielson
Digital Equipment Corp.

Dr. Frank Gadek
Allentown College

Dr. Thomas M. Gallie, Jr.
Duke University

Daniel Garigan
University of Missouri

Martell J. Gee
University of Dayton

Robert J. Gettelfinger
Educational Testing Service

Prof. Allan T. Gifford
Lowell Technological Institute

Dr. James E. Gilbert
Northeastern University

Dr. Robert Gillespie
University of Washington

Anthony S. Glockler
Educational Testing Service

Albert Gold
The Rockefeller University

Dr. Martin Greenberger
The Johns Hopkins University

Frederick A. Gross
Systems & Computer Technology Corp.

Dr. Stuart Grout
Boston University

Neale S. Grunstra
University of Pittsburgh

James E. Guertin
University of Pennsylvania

John L. Gunter
Rochester Institute of Technology

Stanley Habib
Polytechnic Institute of Brooklyn

Michael A. Hall
Auerbach Associates, Inc.

Steven Hall
The Johns Hopkins University

John M. Halloran
Villanova University

Peter Hanlon
University of Saskatchewan

Lt. Col. Harold C. Hannaway
U. S. Military Academy

Thomas R. Harbron
Anderson College

Dr. David O. Harris
University of California - S.B.

Fred M. Harris
University of Chicago

Hobart D. Harvey
Concord College

Dr. Robert Hayes
Becker and Hayes, Inc.

George G. Heller
Association for Computing Mach.

Mrs. Mary Hermanowski
C. W. Post College

Bertram Herzog
Merit Computer Network

Art Hiley
Medical College of Wisconsin

Dean Arthur N. Hofstetter
West Virginia University

Thomas J. Houser
Millersville State College

Dr. Glenn W. Howard
Queens College of the City Univ.

Dr. John A. Hrones
Case Western Reserve University

A. B. Huang
Georgia Institute of Technology

Prof. Richard R. Hughes
The University of Wisconsin

G. A. Hutchison
University of Alabama-Birmingham

Edmund C. Jacobson
College Entrance Examination Board

Betty L. Jahr
Wilkes College

Solis James
The Johns Hopkins University

Ralph W. Johanson
Bentley College (NERComP)

L. Ensign Johnson
Vanderbilt University

Jeremy E. Johnson
University of Maine

Stanley L. Jones
The University of North Carolina
at Greensboro

Dr. Donald L. Katz
The University of Michigan

William B. Kehl
University of California

Eugene Keenoy
Newark State College

Sister Mary K. Keller
Clarke College

Mrs. Brigitte L. Kenney
Drexel University

Allen Kent
University of Pittsburgh

John Kershner
University of Pennsylvania

H. Eugene Kessler, Exec. Director
EDUCOM

Robert Kezell
Temple University

Frederick G. Kilgour
Ohio College Library Center

Dr. Daniel B. Killeen
Tulane University

Sangyol Kim
Essex County Community College

Shepard Kimberly
Educational Testing Service

R. B. King
IBM Corporation

William W. Klaproth
IBM Corporation

William I. Konigsford
New Jersey Department of Higher Educ.

Robert F. Korinke
IBM Corporation

John Crowll
Chronicle of Higher Education

E. R. Krueger
University of Colorado

William W. Kuhn
St. Joseph's College

Mrs. Carolyn P. Landis, Secretary
EDUCOM

John F. Langdon
Loyola University

Richard Laverty
University of Vermont

Thomas P. Lavin
Penna. Dept. of Education

Dr. Calvin B. T. Lee
Boston University

John LeGates
EIN Director, EDUCOM

Dr. Richard Lehman
Director, MERC

Dr. J.C.R. Licklider
Mass. Institute of Technology

Paul R. Linfield,
Franklin and Marshall College

George Lipka
C. W. Post College

R. L. Logan
Argonne National Lab. Library

David J. Lyons
Rockefeller University

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New York University

Charles McClintock
University of Pennsylvania

Prof. Robert McConnell
Union College

Laurence C. McGinn
Temple University

John McGowan
Northwestern University

William J. McKeffery
Virginia Polytechnic Inst.
and State University

Robert H. Maier
University of Wisconsin-Green Bay

Dr. George G. Mallinson
Western Michigan University

Harold Manley
University of Pennsylvania

Thomas E. Manore
Old Dominion University

Mary F. Mansey
Tombrock College

D. E. Mapother
University of Illinois

LeRoy B. Martin Jr.
North Carolina State University

T. R. Martin
Marquette University

Dr. Frank N. Marzocco
Cleveland State University

Joseph E. Matar
Marquette University

David Matheson
Digital Equipment Corp.

Robert Mautz
State University System
of Florida

Dr. John M. Mays
Office of Science and Technology

Fountain Meadows
University City Science Center

Chet Meek
Indiana University

Dr. Arthur S. Melmed
National Science Foundation

John P. Menard
University of Maryland

Daniel Merrill
Oberlin College

Capt. Isaac S. Metts
Walter Reed Army Institute
of Research

Dr. Irvin A. Miller
Drexel University

Joseph G. K. Miller
University of Pittsburgh

Robert Miller
Marquette University

Robert L. Miller
The University of North
Carolina-Greensboro

Ronald Miller
New England Board of
Higher Education

James G. Miller
Cleveland State University

Russell C. Mills
University of Kansas Med. Center

Mrs. Beatrice Mittelman
Teachers College

Don Mittleman
Notre Dame University

B. Mittman
Northwestern University

K. L. Montgomery
University of Pittsburgh

Miss Jane Moorman
Barnard College

Mrs. Judy Morgan
Educational Testing Service

James L. Morgan
State University System
of Florida

Louis R. Morrell
Smith College

Dr. J. C. Morrow
University of North Carolina

Dr. Charles J. Mosmann
Consultant, Corona Del Mar, Calif.

Dr. Charles E. Moulton
Beaver College

Dr. John L. Murray
Catonsville Community College

Anthony Murray
IBM Corporation

Donald Murray
University of Missouri

David A. Neal
Indiana University

Richard B. Nichols
American Telephone and
Telegraph Company

William A. Niskanen
Office of Management of Budget

Dr. Arthur J. Noetzel
John Carroll University

J. Carroll Notestine
Ohio State University

Michael L. O'Connell
Smith College

Robert G. Ogilvie
The American University

Dr. Michael O'Hagen
Southern Methodist University

John P. O'Haren
Franklin & Marshall College

James A. Olbrich
Washington State University

Richard Olson
University of Missouri

Thomas J. O'Reilly
Saint Joseph's College

Father John L. Ostdiek, O.F.M.
Quincy College

James J. Pallante
Glassboro State College

Donald B. Partridge
Philadelphia College Textiles
and Science

Wayne Patterson
University of Vermont

Glenn W. Peardon
University of Saskatchewan

Richard Pearson
The John Jay College - CUNY

Charles Pepper
Twentieth Century Fund

Wayne L. Perry,Jr.
Eastern Baptist College

Dr. William J. Pervin
Drexel University

Paul J. Plourde
Amherst College

Dr. James Poage
Princeton University

Roy Poust
Digital Equipment Corp.

John R. Pruett
Bryn Mawr College

Thomas Raab
Temple University

Dr. Anthony Ralston
State University of New York
at Buffalo

F. W. Rambo
Temple University

Frank Reilly
Tombrock College

Fred Reinner
The Johns Hopkins University

David Remis
Temple University

James H. Reynolds
Colgate University

Roderick R. Ricard, Jr.
University of New Hampshire

Dr. Lawrence G. Roberts
Advanced Projects Research Agency

Michael M. Roberts
Stanford University

Robert J. Robinson
State University of New York - Albany

Saul Rosen
Purdue University

Ronald Rosenberg
Michigan State University

Judith S. Rowe
Princeton University

Harry Rowell
Carnegie-Mellon University

Dale Rummer
University of Kansas

John Rudan
Cornell University

Ronald Rutledge
Carnegie-Mellon University

Frank Rybicki
Temple University

Mrs. Sue A. Salmons
Queens College - CUNY

Martin Saunders
Yale University

Edward Schatz
Carnegie-Mellon University

Dr. Petty Scheinok
Hahnemann Medical College

Paul Schmidt
Richmond College - CUNY

John Schmitt
University of Pennsylvania

Mrs. Barbara Schmitter
Barnard College

R. Ames Schroeder
Duke University

R. G. Selfridge
University of Florida

Gray H. Selleur
Millersville State College

Dr. John R. Senior
University of Pennsylvania

T. W. Sexton
Charles County Community College

A. P. Shalhoup
IBM Corporation

Brian Shenton
University of Pennsylvania

Fred H. Simmons
Florida State University System

Paul W. Sire
University of Vermont

James L. Smith
University of Baltimore

Kerry Smith
American Assoc. for Higher Educa.

Peter J. Smith
Digital Equipment Corporation

Richard L. Snyder
Drexel University

Prof. N.E. Sondak
Worcester Polytechnic Institute

Dr. Harry A. Sperber
Pennsylvania State University

Dean Robin E. Spock
City University of New York

Mrs. Annette H. Sproull
Michigan State University

E. F. Staiano
Bucknell University

Einar Stefferud
Einar Stefferud & Associates

James Steimle
Thornton Community College

Dr. A. A. Sterns
University of Georgia

Harold Stewart
Beaver College

August Swanson, M.D.
Assoc. of American Medical Colleges

Vincent Swoyer
University of Rochester

Dr. John R. Tabb
Old Dominion University

Bruce L. Taylor
Educational Testing Service

Charles G. Taylor
IBM Corporation

Dr. Robert Taylor
Teachers College

Dr. Byron W. Thorsen
Wittenberg University

Louis Vagianos
Dalhousie University

Frank Verbrugge
University of Minnesota

John Walker
Lehigh University

Robert A. J. Walker, M.D.
Hahnemann Medical College

Dr. Charles H. Warlick
The University of Texas - Austin

Jesse Webb
Educational Testing Service

Dr. Joachim I. Weindling
Polytechnic Institute of Brooklyn

Dr. Randall Whaley
University City Science Center

Bard F. White
RELCV

John White
American College of Life Underwriters

James R. Whiteley
University of Iowa

Victor E. Wichert
Educational Testing Service

Dean E. Belvin Williams
Teachers College

Dr. Leland Williams
Triangle Universities Comp. Center

Mrs. Rebecca Willis
IBM Corporation

Thomas L. Yates
Oregon State University

Dr. Norman Zachary
Harvard Computing Center